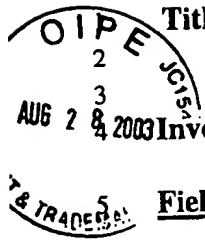


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Title: System and Method for Providing Continuous, Expert Network Critical Care Services from a Remote Location(s)

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**Field of the Invention**

6 This invention relates generally to the care of patients in Intensive Care Units (ICUs).  
7 More particularly this invention is a system and method for care of the critically ill that combines  
8 a real-time, multi-node telemedicine network and an integrated, computerized patient care  
9 management system to enable specially-trained Intensivists to provide 24-hour/7-day-per-week  
10 patient monitoring and management to multiple, geographically dispersed ICUs from both on-  
11 site and remote locations.

**Background of the Invention:**

13 While the severity of illness of ICU patients over the past 15 years has increased  
14 dramatically, the level of and type of physician coverage in most ICUs has remained constant.  
15 Most ICU patients receive brief minutes of attention during morning rounds from physicians  
16 with limited critical care experience. During the remainder of the day and night, nurses are the  
17 primary caregivers, with specialists called only after patient conditions have started to  
18 deteriorate. The result of this mismatch between severity of illness and physician coverage is an  
19 unacceptably high ICU mortality rate (10% nationwide), and a high prevalence of avoidable  
20 errors that result in clinical complications. In 1998, an Institute of Medicine Roundtable  
21 determined that avoidable patient complications were the single largest problem in medical care  
22 delivery. In another prominent 1998 study of 1000 patients, 46% experienced an avoidable  
23 adverse event in care, with 40% of these errors resulting in serious disability or death.

24 The physicians who can remedy this situation are in critically short supply. Numerous  
25 studies have shown that Intensivists (physicians who have trained and board certified in Critical  
Substitute Specification

Care Medicine) can markedly improve patient outcomes. However, only one-third of all ICU patients ever has an Intensivist involved in their care, and the number of Intensivists would need to increase tenfold (nationally) to provide 24-hour coverage to all ICU patients. With the rapid aging of the population, this shortfall of expertise is going to increase dramatically.

Even where Intensivists are present (and especially where they are not), patients suffer from unnecessary variation in practice. There is little incentive for physicians to develop and conform to evidence-based best practices (it takes significant work and a change in behavior to develop and implement them). This variation contributes to sub-optimal outcomes, in both the quality and cost of care delivered to ICU patients.

What is needed is a redesigning of the critical care regimen offered to patients in an ICU. Rather than the consultative model where a periodic visit takes place and the doctor then goes away, a more active 24-hour intensivist managed care is required. Further, technology that leverages the intensivists' expertise and standardizes the care afforded to patients in an ICU is required. Further, continuous feedback to improve the practice of intensivists in an ICU is necessary to provide the intervention required to minimize adverse events. This invention seeks to provide new methods for managing and delivering care to the critically ill.

Attempts to automate various aspects of patient care have been the subject of various inventions. For example, U.S. Patent No. 5,868,669 to Iliff was issued for "Computerized Medical Diagnostic and Treatment Advice System." The disclosed invention is for a system and method for providing computerized knowledge based medical diagnostic and treatment advice to the general public over a telephone network.

U.S. Patent No. 5,823,948 to Ross, Jr. et al was issued for "Medical Records Documentation, Tracking and Order Entry System". The disclosed invention is for a system and

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1 method that computerizes medical records, documentation, tracking and order entries. A  
2 teleconferencing system is employed to allow patient and medical personnel to communicate  
3 with each other. A video system can be employed to videotape a patient's consent.

4 U.S. Patent No. 4,878,175 to Norden-Paul et al. was issued for "Method for Generating  
5 Patient-Specific Flowsheets By Adding/Deleting Parameters." The disclosed invention is for an  
6 automated clinical records system for automated entry of bedside equipment results, such as an  
7 EKG monitor, respirator, etc. The system allows for information to be entered at the bedside  
8 using a terminal having input means and a video display.

9 U.S. Patent No. 5,544,649 to David et al. was issued for "Ambulatory Patient Health  
10 Monitoring Techniques Utilizing Interactive Visual Communications." The disclosed invention  
11 is for an interactive visual system, which allows monitoring of patients at remote sites, such as  
12 the patient's home. Electronic equipment and sensors are used at the remote site to obtain data  
13 from the patient, which is sent to the monitoring site. The monitoring site can display and save  
14 the video, audio and patient's data.

15 U.S. Patent No. 5,867,821 to Ballantyne et al. was issued for "Method and Apparatus for  
16 Electronically Accessing and Distributing Personal Health Care Information and Services in  
17 Hospitals and Homes." The disclosed invention is for an automated system and method for  
18 distribution and administration of medical services, entertainment services, and electronic health  
19 records for health care facilities.

20 U.S. Patent No. 5,832,450 to Myers et al. issued for "Electronic Medical Record Using  
21 Text Database." The disclosed invention is for an electronic medical record system, which stores  
22 data about patient encounters arising from a content generator in freeform text.

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1        U.S. Patent No. 5,812,983 to Kumagai was issued for "Computer Medical File and Chart  
2        System." The disclosed invention is for a system and method which integrates and displays  
3        medical data in which a computer program links a flow sheet of a medical record to medical  
4        charts.

5        U.S. Patent No. 4,489,387 to Lamb et al. was issued for "Method and Apparatus for  
6        Coordinating Medical Procedures." The disclosed invention is for a method and apparatus that  
7        coordinates two or more medical teams to evaluate and treat a patient at the same time without  
8        repeating the same steps.

9        U.S. Patent No. 4,731,725 to Suto et al. issued for "Data Processing System which  
10       Suggests a Pattern of Medical Tests to Reduce the Number of Tests Necessary to Confirm or  
11       Deny a Diagnosis." The disclosed invention is for a data processing system that uses decision  
12       trees for diagnosing a patient's symptoms to confirm or deny the patient's ailment.

13       U.S. Patent No. 5,255,187 to Sorensen issued for "Computer Aided Medical Diagnostic  
14       Method and Apparatus." The disclosed invention is for an interactive computerized diagnostic  
15       system which relies on color codes which signify the presence or absence of the possibility of a  
16       disease based on the symptoms a physician provides the system.

17       U.S. Patent No. 5,839,438 to Chen et al. issued for "Intelligent Remote Visual Monitoring  
18       System for Home Health Care Service." The disclosed invention is for a computer-based remote  
19       visual monitoring system, which provides in-home patient health care from a remote location via  
20       ordinary telephone lines.



1        U.S. Patent No. 5,842,978 to Levy was issued for "Supplemental Audio Visual  
2    Emergency Reviewing Apparatus and Method." The disclosed invention is for a system which  
3    videotapes a patient and superimposes the patient's vital statistics onto the videotape.

4        While these invention provide useful records management and diagnostic tool, none of  
5    them provides a comprehensive method for monitoring and providing real time critical care at  
6    disparate ICU's. In short, they are NOT designed for critical care. Further, none of these  
7    inventions provide for the care of a full time intensivist backed by appropriate database and  
8    decision support assistance in the intensive care environment. What would be useful is a system  
9    and method for providing care for the critically ill that maximizes the presence of an intensivist  
10   trained in the care of the critically. Further such a system would standardize the care in ICU's at  
11   a high level and reduce the mortality rate of patients being cared for in ICU's

12    **Summary of the Invention:**

13        The present invention provides a core business of Continuous Expert Care Network  
14    (CXCN) solution for hospital intensive care units (ICUs). This e-solution uses network,  
15    database, and decision support technologies to provide 24-hour connectivity between Intensivists  
16    and ICUs. The improved access to clinical information and continuous expert oversight leads to  
17    reduced clinical complications, fewer medical errors, reduced mortality, reduced length of stay,  
18    and reduced overall cost per case.

19        The technology of the present invention as explained below can be implemented all at  
20    once or in stages. Thus the technology, as more fully explained below is available in separate  
21    components to allow for the fact that hospitals may not be able to implement all of the  
22    technology at once. Thus modular pieces (e.g. videoconferencing, vital sign monitoring with

1 smart alarms, hand-held physician productivity tools, etc.) can be implemented, all of which can  
2 add value in a stand-alone capacity. First amongst these offerings will be an Intensivist Decision  
3 Support System, a stand-alone software application that codifies evidence-based, best practice  
4 medicine for 150 common ICU clinical scenarios. These support algorithms are explained more  
5 fully below.

6 The "Command Center" model, again as more fully set forth below, will ultimately give  
7 way to a more distributed remote management model where Intensivists and other physicians can  
8 access ICU patients and clinicians (voice, video, data) from their office or home. In this  
9 scenario, the present invention will be available in hospital applications that centralize ICU  
10 information, and offer physicians web-based applications that provide them with real-time  
11 connectivity to this information and to the ICUs. This access and connectivity will enable  
12 physicians to monitor and care for their patients remotely. These products will be natural  
13 extensions and adaptations of the present invention and the existing applications disclosed herein  
14 that those skilled in the art will appreciate and which do not depart from the scope of the  
15 invention as disclosed herein.

16 The present invention addresses these issues and shortcomings of the existing situation in  
17 intensive care, and its shortfalls via two major thrusts. First, an integrated video/voice/data  
18 network application enables continuous real-time management of ICU patients from a remote  
19 setting. Second, a client-server database application B integrated to the remote care network B  
20 provides the data analysis, data presentation, productivity tools and expert knowledge base that  
21 enables a single Intensivist to manage the care of up to 40 patients simultaneously. The  
22 combination of these two thrusts B care management from a remote location and new,  
23 technology-enhanced efficiency of Intensivist efforts B allows health care systems to  
Substitute Specification

1 economically raise the standard of care in their ICUs to one of 24x7 continuous Intensivist  
2 oversight.

3 It is therefore an object of the present invention to reduce avoidable complications in an  
4 ICU.

5 It is a further object of the present invention to reduce unexplained variations in resource  
6 utilization in an ICU.

7 It is a further objective of the present invention to mitigate the serious shortage of  
8 intensivists.

9 It is yet another objective of the present invention to reduce the occurrence of adverse  
10 events in an ICU.

11 It is a further objective of the present invention to standardize the care at a high level  
12 among ICUs.

13 It is yet another objective of the present invention to reduce the cost of ICU care.

14 It is yet another objective of the present invention to dramatically decrease the mortality  
15 in an ICU.

16 It is yet another objective of the present invention to bring information from the ICU to  
17 the intensivist, rather than bring the intensivist to the ICU.

18 It is a further objective of the present invention to combine tele-medical systems  
19 comprising two-way audio/video communication with a continuous real time feed of clinical  
20 information to enable the intensivist to oversee care within the ICU.

21 It is a further objective of the present invention to allow intensivists to monitor ICUs  
22 from a site remote from each individual ICU.

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1           It is a further objective of the present invention to bring organized detailed clinical  
2 information to the intensivist, thereby providing standardized care in the ICU.

3           It is yet another objective of the present invention to utilize knowledge-based software to  
4 use rules, logic, and expertise to provide preliminary analysis and warnings for the intensivists.

5           The present invention comprises a command center/remote location, which is  
6 electronically linked to ICUs remote from the command center/remote location. The command  
7 center/remote location is manned by intensivists 24 hours a day, seven days per week. Each ICU  
8 comprises a nurse's station, to which data flows from individual beds in the ICU. Each patient in  
9 the ICU is monitored by a video camera, as well as by clinical monitors typical for the intensive  
10 care unit. These monitors provide constant real time patient information to the nurse's station,  
11 which in turn provides that information over a dedicated T-1 (high bandwidth) line to the ICU  
12 command center/remote location. As noted earlier, the command center/remote location is  
13 remote from the ICU, thereby allowing the command center/remote location to simultaneously  
14 monitor a number of patients in different ICUs remote from the command center/remote  
15 location.

16           At each command center/remote location, video monitors exist so that the intensivist can  
17 visually monitor patients within the ICU. Further, the intensivist can steer and zoom the video  
18 camera near each patient so that specific views of the patient may be obtained, both up close and  
19 generally. Audio links allow intensivists to talk to patients and staff at an ICU bed location and  
20 allow those individuals to converse with the intensivist.

21           Clinical data is constantly monitored and presented to the command center/remote  
22 location in real time so that the intensivist can not only monitor the video of the patient but also  
23 see the vital signs as transmitted from the bedside. The signals from the clinical data and video

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1 data are submitted to a relational database, which comprises 1) standardized guidelines for the  
2 care of the critically ill, 2) various algorithms to support the intensive care regimen, 3) order  
3 writing software so that knowledge-based recommendations and prescriptions for medication can  
4 be made based upon the clinical data, and 4) knowledge-based vital sign/hemodynamic  
5 algorithms that key the intensivist to engage in early intervention to minimize adverse events.

6 The advantage of the present invention is that intensivists see all patients at a plurality of  
7 ICU's at all times. Further, there is a continuous proactive intensivist care of all patients within  
8 the ICU, thereby minimizing adverse events. Intervention is triggered by evidence-based data-  
9 driven feedback to the intensivist so that standardized care can be provided across a plurality of  
10 ICUs.

11 The economic benefits of the present invention are manifold. For the first time, 24-hour  
12 a day, seven day a week intensivist care for patients in an ICU can be obtained. Further, more  
13 timely interventions in the care of the patients can be created by the knowledge-based guidelines  
14 of the present invention, thereby minimizing complications and adverse events. This in turn will  
15 lead to a reduced mortality within the ICU, and hence, a reduced liability cost due to the  
16 dramatic reduction in avoidable errors in health care.

17 By providing timely interventions, the length of stay within the ICU can be greatly  
18 reduced, thereby allowing more critically ill patients to be cared for in the ICU.

19 In addition, by reviewing and standardizing the care afforded to patients in an ICU, a  
20 more standardized practice across a variety of ICUs can be achieved. This will lead to more  
21 cost-effective care within the ICU, and reduced ancillary cost for the care of the critically ill.

22 The overall architecture of the present invention comprises a "pod." The pod comprises a  
23 tele-medicine command center/remote location connected to a plurality multiple ICUs at various

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1 locations. The connection between the command center/remote location and the ICUs is via a  
2 dedicated wide-area network linking the ICUs to the command center/remote location and a team  
3 of intensivists who integrate their services to provide 24-hour, seven day a week care to all of the  
4 pod ICUs.

5 The pod is connected via a wide-area network using dedicated T-1 lines, for example,  
6 with redundant backup. This network provides reliable, high speed secure transmission of  
7 clinical data and video/audio signals between each patient room and the command center/remote  
8 location. The use of a T-1 line is not meant as a limitation. It is expected that more and higher  
9 bandwidth networks will become available. Such high bandwidth networks would come within  
10 the scope of the invention as well.

11 Each patient room is equipped with a pan/tilt/zoom video camera with audio and speaker  
12 to enable full videoconferencing capability. In addition, computer workstations are dedicated for  
13 exclusive physician use in each ICU, preferably at the nurse's station. Intensivists use the  
14 workstations to view patient information, consult decision support information, record their  
15 notes, and generate patient orders.

16 The patient management software used by intensivists is provided across the pod.  
17 Updates and changes made to the record are available at both the ICU and the command  
18 center/remote location for any given patient.

19 Each command center/remote location contains at least three workstations: one for the  
20 intensivist, one for the critical care registered nurse, and one for a clerk/administrative person.

21 The intensivist workstation comprises separate monitors for displaying ICU video images  
22 of patients and/or ICU personnel, output from bedside monitoring equipment, patient clinical  
23 data comprising history, notes, lab reports, etc., and decision support information. The staff at

1 the command center/remote location are able to activate and control the cameras in each patient's  
2 room so that appropriate visual views of the patient can be generated.

3         Intensivists are able to switch between rooms and patients and can monitor at least two  
4 rooms simultaneously via the video screens. Patient data such as X-ray and ECG images are  
5 scanned and transmitted to the command center/remote location upon request of the intensivist.

6         Remote patient management is utilized in the present invention's critical care program to  
7 supplement traditional onsite care. The rationale underlying the remote patient management of  
8 the present invention is that critically ill patients are inherently unstable and require continuous  
9 expert care that is not now offered in existing ICU monitoring regimens. Further, remote  
10 monitoring allows a single intensivist to care for patients in multiple ICU locations, thereby  
11 creating an efficiency that makes continuous care feasible.

12         Remote intensivist care of the present invention is proactive. Intensivists will order  
13 needed therapies and check results of tests and monitor modalities in a more timely fashion than  
14 is currently offered. Patients can be observed visually when needed using the ceiling-mounted  
15 cameras in each room.

16         Command center/remote location personnel communicate with ICU staff through  
17 videoconferencing and through "hot phones," which are dedicated telephones directly linked  
18 between the command center/remote location and the ICU. These communications links are  
19 used to discuss patient care issues and to communicate when a new order has been generated.

20         Intensivists document important events occurring during their shift in progress notes  
21 generated on the command center/remote location computer terminal.

Intensivists detect impending problems by intermittently screening patient data, including both real time and continuously stored vital sign data. Patient severity of illness determines the frequency with which each patient's data is reviewed by the intensivists.

#### **Brief Description of the Figures**

Figure 1A illustrates the logical data structure for billing, insurance and demographic information.

Figure 1B illustrates the logical data structure for billing, insurance and demographic information (cont).

Figure 2A illustrates the command center logical data structure.

Figure 2B illustrates the command center logical data structure (cont).

Figure 3 illustrates the logical data structure for creating a medical history.

Figure 4A illustrates the logical data structure for creating notes relating to patient treatment and diagnosis.

Figure 4B illustrates the logical data structure for creating notes relating to patient treatment and diagnosis (cont).

Figure 4C illustrates the logical data structure for creating notes relating to patient treatment and diagnosis (cont).

Figure 5 illustrates the logical data structure for entry of medical orders.

Figure 6A illustrates the logical data structure for patient care, laboratory testing and diagnostic imaging.

Figure 6B illustrates the logical data structure for patient care, laboratory testing and diagnostic imaging (cont).



1        Figure 7 illustrates the logical data structure for categories of information that are  
2 permitted to be presented to intensivists and other care givers by the system.

3        Figure 8A illustrates the logical data structure for documenting patient vital signs.

4        Figure 8B illustrates the logical data structure for documenting patient vital signs (cont).

5        Figure 9 illustrates the distributed architecture of the present invention.

6        Figure 10 illustrates the system architecture of the present invention.

7        Figure 11 illustrates the decision support algorithm for decision support algorithm for  
8 diagnosis and treatment of pancreatitis.

9        Figure 12 illustrates the vital signs data flow.

10       Figure 13A illustrates capture and display of diagnostic imaging.

11       Figure 13B illustrates establishing videoconferencing in the present invention.

12       Figure 14 illustrates the physician resources order writing data interface of the present  
13 invention.

14       Figure 15 illustrates the physician resources database data interface of the present  
15 invention.

16       Figure 16 illustrates the automated coding and billing system integrated with the  
17 workflow and dataflow of the present invention.

18       Figure 17 illustrates the order writing data flow of the present invention.

19       Figure 18 illustrates the event log flow of the present invention.

20       Figure 19 illustrates the smart alarms implementation of the present invention.

21       Figure 20 illustrates the procedure note creation and line log for the present invention.

22       Figures 21A-B illustrate the acalculous cholecystitis decision support algorithm.

23       Figure 22 illustrates the adrenal insufficiency decision support algorithm.

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1       Figure 23 illustrates the blunt cardiac injury decision support algorithm.

2       Figures 24A-B illustrate the candiduria decision support algorithm.

3       Figures 25A-B illustrate the cervical spine injury decision support algorithm.

4       Figures 26A-B illustrate the oliguria decision support algorithm.

5       Figures 26C-D illustrate the oliguria decision support algorithm (cont).

6       Figure 26E illustrates the oliguria decision support algorithm (cont).

7       Figures 27A-B illustrate the open fractures decision support algorithm.

8       Figures 28A-B illustrate the pancreatitis decision support algorithm.

9       Figures 29A-B illustrate the penicillin allergy decision support algorithm

10      Figures 30A-B illustrate the post-op hypertension decision support algorithm

11      Figure 31A illustrates the pulmonary embolism decision support algorithm

12      Figure 31B illustrates the pulmonary embolism decision support algorithm (cont)

13      Figure 32 illustrates the seizure decision support algorithm

14      Figures 33A-B illustrate the SVT determination decision support algorithm

15      Figure 33C illustrates the SVT unstable decision support algorithm

16      Figures 34A-B illustrate the wide complex QRS Tachycardia decision support algorithm

17      Figure 34C illustrates the wide complex QRS Tachycardia decision support algorithm

18      (cont)

19      Figure 35A illustrates the assessment of sedation decision support algorithm

20      Figure 35B illustrates the assessment of sedation decision support algorithm (cont)

21      Figure 36 illustrates the bolus sliding scale midazolam decision support algorithm

22      Figure 37 illustrates the sedation assessment algorithm decision support algorithm

23      Figure 38 illustrates the short term sedation process decision support algorithm

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1        Figure 39 illustrates the respiratory isolation decision support algorithm

2        Figure 40 illustrates the empiric meningitis treatment decision support algorithm

3        Figure 41A illustrates the ventilator weaning decision support algorithm

4        Figure 41B illustrates the ventilator weaning decision support algorithm (cont)

5        Figure 42 illustrates the warfarin dosing decision support algorithm

6        Figure 43 illustrates the HIT-2 diagnostic decision support algorithm

7        **Definitions of Terms and Data**

8            In the following Detailed description of the Invention, a number of modules and  
9        procedures are described. For purposes of definitions, the following module definitions apply  
10       and are more fully amplified in the descriptions of the figures that follow:

11       **Term Definitions:**

12            Following are a series of definitions for certain terms used in this specification:

13            Insurance carrier: This is a table of all the valid insurance carriers listed in the system of  
14       the present invention.

15            Patient guarantor: Provides the insurance guarantor information for a given patient.

16            Patient information: Provides demographic information for each patient.

17            Medical event date history: This contains the various disorders of the patient and the  
18       dates associated with major medical events relating to those disorders.

19            Medical history: Contains non-major system medical history of a patient.

20            Drug: Contains what medication and allergies have been identified for a patient at  
21       admission.

22            Address: Contains the address or addresses for a given patient.

1 Patient visit: There may be multiple records for any given patient, since the patient may  
2 visit the ICU on more than one occasion. This file contains a record of each visit to an ICU by a  
3 patient.

4 Physician-patient task: Contains the task that had been defined for each patient.

5 Present illness: This contains a textural description of the patient illness for the specific  
6 ICU visit.

7 Physical exam: This contains the information gathered as a result of a physical  
8 examination of the patient during the admission to the ICU.

9 Surgical fluids: This provides all the information related to the fluids provided during  
10 surgery.

11 Surgery: This contains all information pertaining to any surgical procedure performed on  
12 a patient while the patient is at the ICU.

13 Patient admit: This provides general information that needs to be gathered when a patient  
14 is admitted into the ICU.

15 Medical orders: This provides the general information for all types of medical orders  
16 associated with a given patient.

17 Daily treatment: This contains the treatment provided for a given patient on a given day.

18 Daily diagnosis: This contains the daily diagnosis for a given patient, which includes  
19 neurological, cardiological, pulmonary, renal, endocrinological, and any other diagnosis that may  
20 be associated with a patient.

21 Vital sign information is also critical to the administration of care in the ICU. A number  
22 of different modules collect information relating to patient vital signs. For example:

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1 Patient admit: This provides the general information that needs to be gathered when a  
2 patient is admitted to the ICU.

3 Patient visit: This contains a record of each visit to an ICU by a patient.

4 Patient: Provides demographic information for each patient.

5 Vital sign header: This contains general information related to the vital sign data for the  
6 particular patient.

7 Vital sign: Contains the vital sign data taken at specific intervals for a given patient.

8 Hospital: This contains identifying information for a particular hospital where the care is  
9 given.

10 ICU bed: Contains the association for identifying which beds are in a given ICU.

11 Command center/remote location definitions and modules have also been created for the  
12 present invention to allow for the orderly storage and retrieval and entering of data. For  
13 example:

14 Physician-physician (such as nurses and LPN and the like): Contains the names of all of  
15 the physicians and physician extenders for the command center/remote location as well as for  
16 ICUs associated with the command center/remote location.

17 Communication: Contains all of the various types of communication vehicles used to  
18 contact an individual physician or physician extender.

19 Physician role: Contains the role a physician is playing for a given patient, (i.e., primary  
20 care, consultant, etc.)

21 Patient: Provides demographic information for each patient.

22 Command center/remote location: Provides identifying information for a particular  
23 command center/remote location.

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1 Hospital: Contains identifying information for a particular hospital wherein an ICU is  
2 located.

3 ICU: Contains identifying information for an ICU at a hospital.

4 ICU bed: Contains the association for identifying which beds are in a given hospital.

5 ICU patient location: Provides the association between an ICU and a patient and  
6 identifies where a patient is located within an ICU in a particular hospital.

7 The order entry functionality of the present invention provides a critical service for  
8 obtaining information on the patient during admission, medical orders, and procedures provided  
9 to the patient during the ICU stay. For example:

10 Radiology: Contains all radiology performed on a particular patient.

11 Radiology results: Contains the results of each radiology test performed on the particular  
12 patient.

13 Drugs: Contains all relevant information for all the drugs that a patient has been  
14 administered.

15 Laboratory: Contains all laboratory tests ordered for a patient.

16 Microbiology result: Contains the results of microbiology organisms taken on a patient.

17 Laboratory result: Contains the results for a laboratory test ordered for a particular  
18 patient.

### 19 **Detailed Description of the Invention**

20 The present invention is a system and method for remote monitoring of ICU's from a  
21 distant command center/remote location. By monitoring a plurality of ICU's remotely,  
22 intensivists can better spread their expertise over more ICU beds that heretofore achievable. The

1 presence of 24-hour a day/7 day-per-week intensivist care dramatically decreases the mortality  
2 rates associated with ICU care.

3 Referring to Figures 1A and 1B, the Billing and Demographic data structure of the  
4 present invention is illustrated. Patient demographic information **9010** is collected on the  
5 particular patient. This information comprises all the typical kinds of information one would  
6 normally gather on a patient such as first name, last name, telephone number, marital status, and  
7 other types of information. Patient insurance information **9012** is collected and associated with  
8 the patient demographic information **9010**. Patient insurance information **9012** relates to  
9 information on the type of accident and related information such as employment, employer  
10 name, place of service, and other information that would relate to the accident that actually  
11 occurred (if at all) and which would have to be reported to an insurance agency. This  
12 information is associated with the patient demographic information which assigns the unique  
13 patient ID to the particular patient.

14 Insurance plan information **9008** is also created and stored and comprises insurance  
15 carrier ID's, the plan name, policy number, and group number. This information on the  
16 insurance plan **9008** is also associated with the patient ID and demographic information **9010**.

17 Physician information **9002** is also created and stored for each physician associated with  
18 the system of the present invention. Information such as first and last name, credentials, and  
19 other information concerning the physician is saved. In addition, the physician's role is  
20 identified **9004** and information concerning the physician and the physician's role is associated  
21 with the particular patient via the patient ID stored in the demographic information **9010**.

22 Patient's are entered into the hospital by a hospital representative **9006** who has a  
23 representative ID which also is ultimately associated with the patient ID. In addition,

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1 communications data **9000** is stored concerning how a representative can be reached (cell phone,  
2 home phone etc.).

3 Referring now to Figure 1B, the Overall Billing and Insurance data structure is  
4 illustrated. An insurance provider number **9014** is also stored in the system. Each physician is  
5 given a provider number and provider ID by each insurance company. Thus data must be stored  
6 regarding the ID that is given to a particular physician by each insurance provider. This  
7 information is also stored and can be associated ultimately with treatment of the patient.

8 Each patient admitted to the hospital and to the ICU has a patient visit ID associated with  
9 the patient **9017**. This visit ID has patient ID information, ICU information, admission date, and  
10 other information relevant to the specific visit. This information is illustrated in Figure 1B. The  
11 visit ID **9017** is associated with the patient ID **9010** so that each visit can be tracked by patient.

12 Insurance carrier information **9018** is stored by the system and is associated with the  
13 insurance plan information **9008** as appropriate. Thus the particular insurance carrier with its  
14 name, address, and other identifying information **9018** is associated with the type of plan **9008**  
15 carried by the patient. The insurance carrier information **9018** together with the insurance plan  
16 information **9008** is associated with the patient via the patient ID information **9010**.

17 Patient address information **9020** and **9022** are collected for each individual patient and  
18 associated with the patient demographic information **9010**. If there is a patient guarantor, this  
19 information is obtained and stored with information on the guarantor **9026**. Such information as  
20 the guarantor's first and last name, date of birth, and other information is stored and is illustrated  
21 in Figure 1B. Further, the guarantor's address **9024** is also collected and ultimately associated  
22 with the patient demographic information **9010**.

23 Referring to Figures 2A and 2B, the Command Center logical data structure is illustrated.

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1 The various information associated with demographic and insurance information is again used to  
2 manage the care and operations of the command center. Therefore, communications information  
3 9000 is combined with physician and physician extender (i.e. nurse, LPN and the like)  
4 information 9002 and physician role 9004 to be associated with the demographic information  
5 9010. The patient visit information 9017 together with this information is associated with the  
6 patient's location which has a unique identifier 9030. Each location ID has patient ID  
7 information and visit ID information associated with it.

8 Referring now to Figure 2B, the Command Center logical data structure illustration  
9 continues. Each ICU bed has an associated location ID which comprises hospital ICU  
10 information, room number, and bed number 9038. In addition, and as described earlier,  
11 instrumentation such as cameras are also associated with the particular patient. Therefore the  
12 camera setting 9040 will have a location ID relating to the ICU bed as well as have camera value  
13 settings and associated camera identifier information.

14 Each ICU bed 9038 is associated with an ICU 9032. Each ICU has information  
15 associated with it that uniquely identifies the ICU as being associated with the particular  
16 hospital, and having particular phone numbers, fax numbers, work space addresses, and other  
17 information, that help to identify the ICU.

18 As noted above, each ICU is associated with a hospital 9034. Each hospital has a unique  
19 identifier, as well as its own name, address, and other identifying information. Further, since  
20 each hospital ICU is to be coordinated through a remote command center, information on the  
21 remote command center 9036 is associated with the hospital information. Each command center  
22 has a unique ID and has associated address information stored as well.

23 Thus in the Command Center logical data structure, patient ID information 9010 is linked

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1 to a patient location **9030** which in turn is associated with an ICU bed **9038** each of which beds  
2 are uniquely associated an ICU **9032** which is associated with a hospital **9034** which in turn has  
3 the ICU managed by a command center **9036**.

4 An integral part of the system of the present invention is the recording of medical history.  
5 Referring to Figure 3, the logical relationship among data elements for medial history is  
6 illustrated. Patient visit information **9017** combined with the physician-physician extender  
7 information **9002** is combined with specific note-taking information **9042**. The note information  
8 comprises the date and time the notes are taken as well as the note type. The note ID is fed  
9 information from the medical history item **9044**, which has its own unique medical ID associated  
10 with it. This information comprises medical text, category of information, and other information  
11 relevant to the medical history. As noted, this information for medical history **9044** is associated  
12 with a note ID **9042**, which in turn is associated with the patient visit and physician information  
13 **9017** and **9002**.

14 Referring to Figure 4A, 4B, and 4C, the note-keeping logical data structure of the present  
15 invention is illustrated. As noted earlier, the note ID **9042** combines information from visit ID,  
16 treating physician, and other information relating to the time the note was entered. Other  
17 information is associated with the note ID. Referring first to Figure 4A, the patient visit  
18 information **9017**, is associated with the note ID **9042**. Various procedural information **9046** is  
19 kept by the system of the present invention and is associated with the visit ID **9017**. Physicians  
20 are able to create free text patient illness notations **9048** and associate them with the note **9042**.  
21 Similarly, free text information regarding functioning of the system **9050** is permitted and also  
22 associated with notes regarding the particular patient and procedure **9042**.

23 Specific notes regarding, for example, surgical procedures are also kept. Surgery notes

1   **9054** are associated with a particular note ID and have such information as anesthesia, surgical  
2   diagnosis, elective information, and other related surgical information. Surgical fluids **9052**  
3   administered during the course of surgery are associated with the surgery information **9054**.  
4   Additionally, any surgical complications **9056** are noted and also associated with the surgery  
5   which in turn has an associated note ID.

6         Referring now to Figure 4B, the logical data structure for notes and its description is  
7   continued. An assessment plan **9058** is created and associated with the same note ID for the  
8   particular patient. The plan has a free text field that allows a physician to create the appropriate  
9   assessment plan and associate it with a note ID **9042**.

10        Various daily notes are also kept and associated with the individual note ID **9042**. For  
11   example, the daily mental state **9060** is recorded to document the mental state of the patient. The  
12   daily treatment **9062** administered to the patient is associated with the unique note ID. The daily  
13   diagnosis **9068** is also created and associated with unique note ID **9042**.

14        Any unstable conditions are also noted **9070** and records kept of those conditions.  
15   Similarly mortality performance measures (MPM) information **9072** is kept and associated with  
16   the unique note ID. To the extent that any physical exam **9074** is administered, that physical  
17   exam and any free text created by the physician is associated with the unique ID and records  
18   kept. Allergy information **9076** for the particular patient is also created and stored along with the  
19   allergy type, and allergy name. This information is uniquely associated with the note ID.

20        Referring now to Figure 4C, the Logical Data Structure for the Notes Creation and Storage  
21   description is continued. A specific note item record **9078** is also kept and associated with  
22   unique note ID. This note item comprises the principal diagnosis, the chief complaint, the past  
23   history of the patient, the reason for the note, and various other identifications and flags of

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1 information which help in documenting the patient's condition.

2 Any drugs that are administered to the patient, including dosage, type, and number 9086

3 is kept and associated with the unique note ID 9042.

4 Procedural note items are also documented 9082. Procedural notes involve the

5 procedural type, the principal diagnosis, the procedural location, procedural indications, and

6 other information of a procedural nature. Procedural description information 9088 is kept as

7 input to the procedural note item. This information is also associated with a procedural

8 evaluation 9084 which comprises text describing the procedural evaluation that occurred. These

9 three items, the procedural description 9088, procedural evaluation 9084, and procedural note

10 items 9082, are all uniquely associated with the note ID 9042.

11 Referring now to Figure 5, the Logical Data Structure of the Medical Order Functionality

12 of the Present Invention is illustrated. Each medical order 9092 has a unique order ID associated

13 with it. This information derives its uniqueness from the visit ID, the representative ID, and

14 various information about the date in which the order was created and other such relevant

15 information. Any non-drug orders 9090 are associated with a unique non-drug order ID. The

16 order is classified, identified, and free text can be created by the physician to describe the order.

17 This information in the non-drug order 9090 is associated with the unique medical order for that

18 particular patient 9092.

19 Again physician and physician extender identification information 9002 is also uniquely

20 associated with the medical order to identify the physician involved in creating the particular

21 order in question.

22 Drug orders 9094 are created each with its own unique drug order ID. Various

23 information is collected as part of the drug order including the type of drug, the dosage, start

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1 date, frequency, stop date, to name but a few elements typical of a drug order. The drug order  
2 information **9094** is associated with the unique medical order ID **9092** assigned to that particular  
3 patient. All of the medical order information is associated with patient visit information **9017**  
4 which allows that information to be uniquely identified with a particular patient for a particular  
5 visit.

6 Referring again to Figure 4C, the system is also capable of annotating and storing various  
7 log items **9080**. For example, an event log item is given a number, a patient profile item has its  
8 own number, as do neurological, cardiographic, pulmonary, renal, and other events can have log  
9 items associated with them and may be used as input to any of the note taking of the present  
10 invention.

11 Referring to Figure 6A and 6B, the logical data structure of the patient care functionality  
12 of the present invention is illustrated. Each patient visit with its unique ID **9017** has a number of  
13 other pieces of information associated with it. For example, physician-patient tasks are tracked  
14 **9098** and have a unique task ID associated with them. The patient code status **9096** is  
15 documented and associated with the physician-patient task **9098** task ID. This information is  
16 uniquely associated with the patient visit via the the patient visit ID **9017**.

17 Laboratory information **9100** has a unique lab ID associated with it. That information is  
18 keyed to the visit ID and records the specimen taken, the date it was taken, and various other  
19 information germane to the laboratory procedure involved. Other lab procedures **9102** are also  
20 documented with another unique ID. "Other" lab ID is associated with the laboratory ID **9100**  
21 which again is uniquely associated with the particular patient.

22 Microbiological studies **9104** are documented together with the date and the date taken  
23 and the type of study involved. Any study of microorganisms **9106** is documented with a unique

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1 microorganism ID. Micro sensitivities **9108** which record the sensitivity to microorganisms and  
2 certain antibiotics is recorded and associated with the microorganism ID **9106**. This information  
3 in turn is associated with a microbiological study **9104**, all of which is associated with the unique  
4 patient visit ID **9107**.

5 Respiratory studies **9101** are also recorded with unique identification numbers and a  
6 description. This information is again associated with the patient visit ID **9107**.

7 Referring now to Figure 6B, the logical data structure of the patient care functionality of  
8 the Present Invention is further illustrated. Other organism studies **9118** are also conducted to  
9 determine any other conditions associated with microorganisms that might exist with the  
10 particular patient. This other organism information **9118** is associated with the microorganism  
11 studies **9106** which in turn is associated with the microbiology category of information of the  
12 present invention **9104**.

13 Various diagnostic imaging also takes place and is recorded. This image information  
14 **9114** has unique image ID associated with each image and comprises associated information  
15 such as the image type, the date performed, and other information relevant to the diagnostic  
16 imagery. The result of the image taken **9116** is also uniquely identified with the image ID and a  
17 unique image result ID. This information is associated with the image information **9114** which  
18 again is uniquely associated with the patient visit ID.

19 Various intake and output for the patient's biological functioning is recorded **9110**.  
20 Intake and output total **9112** is recorded and uniquely associated with the intake/output  
21 identification note **9110**. Intake/output totals **9112** also comprised the weight the total taken in,  
22 the total out, and five-day cumulative totals for biological functioning of the particular patient.

23 Referring to Figure 7, The Logical Data Structure Concern with Reference Information

1 for the present invention is illustrated. This data structure allows only certain ranges of data to  
2 be input by care givers into the system. This is accomplished by having categories of  
3 information **9120** each category capable of having only certain values. Similarly, each type of  
4 data **9126** associated with each category is only permitted to have certain values. This  
5 combination of Category and Type results in a Combined ID **9122** which can be used in  
6 combination with certain values **9128** to create a value and combination **9124** that can be  
7 presented to a care giver viewing and entering data. This effectively limits errors in data entry  
8 by only allowing certain values to be entered for given types of data. For example, if only  
9 milligrams of a medication are supposed to be administered, this data structure prevents a care  
10 giver from administering kilograms of material since it is not a permitted range of data entry.  
11 The “nextkey” function **9027** is the function that keeps track of the ID’s that are given during the  
12 administration of the present invention. This function insures that only unique ID’s are given  
13 and that no identical ID’s are given to two different patient’s for example.

14 Referring to Figure 8A, the Logical Data Structure of the Vital Signs Functionality of the  
15 Present Invention is illustrated. Vital sign header information **9120** is created and uniquely  
16 associated with the visit ID for the particular patient. This header information comprises a date-  
17 time stamp combined with hospital information, medical reference numbers, and identification of  
18 the patient. Vital sign details **9122** are also created and uniquely date-time stamped and  
19 associated with the particular visit ID for the patient. This information comprises all manner of  
20 vital sign information relating to blood pressure, respiration, and other factors. Vital sign  
21 information is associated with the patient visit **9017** and the demographic information concerning  
22 the patient **9016**. Such associations of information can be the basis for later studies.

23 Referring to Figure 8B, Additional Vital Sign Logical Data Structures are illustrated. For

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1 example, a vital sign log header **9120** is created using the unique hospital ID and medical record  
2 numbers. Other information such a patient name, and date-time stamp are also stored. Vital sign  
3 log details **9124** are created and associated with the vital sign log header **9120**. For example,  
4 blood pressure measurements, respiration, and other factors are all detailed for a particular  
5 hospital ID. It should be noted that all vital sign data is logged in and kept by the systems of the  
6 present invention. Where vital sign information is received but cannot be associated with a  
7 particular patient, such communications are noted as errors.

8 Vital sign error details **9126** are also recorded and associated with a particular hospital.  
9 Information and the vital sign error detail also comprises heart rate, blood pressure, and other  
10 information. This information is associated with a vital sign error header **9130** which is  
11 associated with the hospital identifier and the patient first and last name and other information.  
12 Various vital sign error codes **9128** exist with the present invention and are used in association  
13 with the vital sign error detail **9126**. This information however relates to communications of  
14 vital sign data that are deemed "errors" as noted above.

15 Care Net patient location **9132** is recorded and associated with a particular hospital ID  
16 and location ID for the particular patient. Carenet is a proprietary product designation of  
17 Hewlett-Packard and is kept by the system of the present invention since it identifies the  
18 equipment from which measurements come. The ICU bed information **9038** is associated with  
19 the Care Net patient location **9132**.

20 Referring to **Figure 9**, the distributed architecture of the present invention is  
21 shown. In concept, the distributed architecture comprises a headquarters component **200**, a  
22 command center/remote location **202**, and a hospital ICU **204**, which, while represented as a  
23 single hospital in this illustration, in the preferred embodiment comprises several hospital ICUs



1 at different locations. The headquarters unit **200** comprises a database server and data  
2 warehouse functionality, together with a patient information front end. The patient information  
3 front end **206** provides patient specific information to the command center/remote location. The  
4 database server/warehouse function **208** comprises the amassed information of a wide variety of  
5 patients, in their various conditions, treatments, outcomes, and other information of a statistical  
6 nature that will assist clinicians and intensivists in treating patients in the ICU. The headquarters'  
7 function also serves to allow centralized creation of decision support algorithms and a wide  
8 variety of other treatment information that can be centrally managed and thereby standardized  
9 across a variety of command center/remote locations. Further, the database server/data  
10 warehousing functionality **208** serves to store information coming from command center/remote  
11 locations replicating that data so that, in the event of a catastrophic loss of information at the  
12 command center/remote location, the information can be duplicated at the command  
13 center/remote location once all systems are up and running.

14 At the hospital ICU **204**, each patient room **232, 234** has a series of bedside monitors and  
15 both video and audio monitoring of each patient in the patient room. Each ICU further has a  
16 nurse's station with a video camera and monitor **230** so that videoconferencing can go on  
17 between the nurses and doctors at the nursing station and those intensivists at the command  
18 center/remote location. The monitoring equipment at the ICU is served by a monitor server **236**,  
19 which receives and coordinates the transmission of all bedside monitoring and nurses station  
20 communication with the command center/remote location. Finally, each ICU has a patient  
21 information front end **228**, which receives and transmits to the command center/remote location  
22 information concerning the identity and other characteristics of the patient.

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1           Command center/remote location **202** comprises its own video capture and monitoring  
2   capability **212** in order to allow the intensivists to view the patients and information from the  
3   bedside monitoring as well as to have videoconferencing with the nursing station and with  
4   patients as the need arises. Information from the monitor server **236** at the hospital ICU is served  
5   to an HL7 (the language for transmitting hospital/patient/diagnostic data) gateway **214** to a  
6   database server **222**. In this fashion, information from the bedside monitors can be stored for  
7   current and historical analysis. Monitor front ends **216** and **218** allow technicians and command  
8   center/remote location personnel to monitor the incoming data from the patient rooms in the  
9   ICU. Information from the patient information front end **228** is provided to an application server  
10   **224**, having its own patient information front end **226** for aggregating and assembling  
11   information in the database **222** that is associated with individual patients in the ICU.

12           It is expected that there will be a great deal of concurrent hospital data that is necessary to  
13   the implementation of the present invention. It is therefore expected that there will be a legacy  
14   database system **210** having a front end **220** from which intensivists and command center/remote  
15   location personnel can retrieve legacy database information.

16           Referring to **Figure 10**, a system architecture of one embodiment of the present invention  
17   is illustrated. Headquarters **200** comprises an application server **238**, an NT file server **240**, and  
18   Sun SPARC Enterprise 250 **242** and Enterprise network management system **244**, a Cisco 3600  
19   router **246**, a Cisco 2924 switch **248**, and a hot phone **250**. The application server **238** is  
20   designed to monitor and update those applications used at the command center/remote location.  
21   The NT file server serves to monitor, store, and replicate information coming from the command  
22   center/remote locations. The SPARC Enterprise 250 server **242** is a disc storage server, for  
23   storing and serving information, such as practice guidelines, algorithms, patient information, and

1 all matter of other information records that must be stored in order to support the present  
2 invention. As explained below, the SPARC Enterprise 250 server and other components are such  
3 as routers and switches are commonly used in the ICU, the command center/remote location, and  
4 the headquarters. For example:

5 The Cisco 3600 router is a multi-function device that combines dial access, routing, and  
6 local area network (LAN) to LAN services, as well as the multi-service integration of voice,  
7 video, and data in the same device. This is necessary, since the various command center/remote  
8 locations, headquarters, and intensive care units all must integrate and transmit video, audio, and  
9 data among the various entities.

10 The Cisco 7204 is a router which provides high speed LAN interconnect, virtual private  
11 networks, and Internet access, all of which is required for providing the communication in the  
12 network of the present invention; and

13 The Cisco 2924 switch is an autosensing fast ethernet switch, allowing networked  
14 multimedia and virtual LAN support. Multi-level security is also offered in the switch to prevent  
15 unauthorized users from gaining access and altering switch configuration. These components are  
16 also identified in the figures (below).

17 The particular commercial systems named here are given as but some examples of  
18 equipment available today. The function of these equipment is the important factor. Other  
19 similar or improved equipment can also be utilized.

20 The network management system 244 allows the entire traffic and condition of the  
21 network to be monitored and to allow maintenance to take place. The router 246 and switch 248  
22 is used for communication with the various command center/remote locations that are served by

1 the Headquarters component. The Headquarters component interacts via frame relay with the  
2 command center/remote location 202.

3 Command center/remote location 202 comprises an applications server 262 for the  
4 purpose of running various applications for the intensivists and command center/remote location  
5 staff. The NT file server 264 at the command center/remote location allows patient files,  
6 historical files, algorithms, practice standards, and guidelines, to be served to the clinicians and  
7 intensivists to assist in monitoring the patients. The Sun SPARC Enterprise 250 266 is used to  
8 for storage purposes as noted above. The Enterprise network management system 268 monitors  
9 the overall health of the network of command center/remote locations and intensive care units as  
10 well as the functionality of the individual pieces of equipment within the command  
11 center/remote location. A Cisco 2924 switch 256 and Cisco 7204 router 258, combined with the  
12 Cisco 3600 router 260 allows for point to point communication over a T1 line, with a plurality of  
13 intensive care units located remotely from the command center/remote location. Hot phones 252  
14 and 254 allow communication with the headquarters and the intensive care unit.

15 Intensive care unit 204 comprises a Cisco 2924 switch 272 for the purpose of interfacing  
16 with the various audio-video feeds 274, 276 from the various patient rooms and the nursing  
17 station. A local work station 280 is connected to a scanner 282 which allows data to be input,  
18 scanned, and communicated via the point to point T1 communications to the command  
19 center/remote location. Further, the workstation 280 provides for textual advice and patient  
20 orders to be delivered to the intensive care unit for execution. The intensive care unit also  
21 comprises a laser printer 284 for the printing of patient orders and other information relevant to  
22 the care of intensive care patients.

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Referring to **Figure 11**, the videoconferencing/surveillance/imaging components of the present invention are illustrated. The hospital ICU **204** comprises a series of video cameras **290**, which are located in patient rooms and at the nurse's station. Control for the cameras is provided through an RS424 to RS232 converter **288**, with instructions for imaging emanating from the workstation at the command center/remote location **252** through the ICU workstation **280** through a multi-port serial controller **286**. Video feed from the video cameras **290** is provided to an audio-video switcher **292**, which in turn provides its output to the multi-port serial controller **286** for subsequent viewing at the nurse's station and at the command center/remote location. Of equal importance is a microphone feed from the patient and from the nurses. That microphone **296** provides its signal to an audio line amplifier **294**, which in turn provides an audio feed to the audio-video switcher **292**. In this way, a patient can provide information, as can nurses who are visiting the patient during the course of patient care. It is also important that information of an audio nature be fed to the intensive care unit, both to the patient rooms and to the nurse's station. To do this, the multi-port serial controller **286** provides an audio signal to a reverse audio switcher **298**, which in turn provides information to speakers **300** that are located at the nurse's station as well as at the bedside of the patients. Information to the reverse audio switcher is provided an audio amplifier **302** from information from a video codec **304**, which in turn is connected to the workstation at the ICU. As noted earlier, a scanner **282** is provided, so that information can be scanned and provided to the command center/remote location **202** and a hot telephone **278** communicates with a telephone **252** at the command center/remote location.

Referring to **Figure 12** the vital signs data flow is illustrated. The monitoring system at each ICU bedside comprises a monitoring system for monitoring the vital signs for the patient. The vital sign monitoring system **450** captures vital sign data **452** and transmits that vital sign

1 data 454 using the HL7 language (the standard processing language for hospital data and  
2 information). The processor at the ICU processes the vital sign data for transmission and storage  
3 purposes and transmits that information to the remote location. Vital sign data is then loaded  
4 into the data base 458. The data base for each individual patient is then reviewed and process  
5 rules are applied 460 to the vital sign data. These process rules relate to certain alarming  
6 conditions which, if a certain threshold is reached, provides an alarm to the intensivist on duty.  
7 The vital sign alarm 462 is then displaced to the intensivist who can then take appropriate action.  
8 A typical type of rule processing of the vital sign data might be if blood pressure remains at a  
9 certain low level for an extended period of time, or if heart rate remains high for an extended  
10 period of time. In addition a wide range of other rules are provided which will provide an  
11 audible alarm to the intensivist before a critical situation is reached.

12 In addition to the information being provided to the alarming system for the intensivist,  
13 the vital sign data 464 is also transmitted 466 into a database warehouse 468 comprising vital  
14 sign data 470 from not only the individual patient but from all of the patients being cared for in  
15 the ICU. This database warehouse provides the ability to do data mining for trends that can give  
16 rise to additional process rules and vital sign thresholding. In addition to the transmission of  
17 vital sign data 454 to the remote site, the vital sign data is displayed in real time at the ICU 472.

18 Referring to Figure 13A the diagnostic imaging interaction is illustrated. X-rays for  
19 example, are created and transmitted to the command center 472. Additionally, the information  
20 could be ACT scan, MRI, or any other method of medical diagnostic imaging. The x-ray image  
21 is captured at the command center 474 where it is stored and in addition displayed on the image  
22 monitor 476 for the intensivist to review.

1 Referring to **Figure 13B** the interactive video session is illustrated. A video conferencing  
2 session is established **478** regarding a particular patient in an ICU bed. Using the video cameras  
3 in each room and/or at the nurses station at the ICU, the patient and/or the nurse can be viewed  
4 **480**. On the other end of the video conferencing session is the intensivist who can then both  
5 visually and orally communicate with the patient and/or nurse **482**.

6 Referring to **Figure 14** the physician resources and order writing data interface is  
7 illustrated. The user interface **484** allows the physicians to access physician resources **486**.  
8 These resources provide guideline for the treatment of the critically ill. In this example the  
9 intensivist is requested to enter the antibiotic associated with colitis **488**. The system then  
10 generates a request for a fecal leukocyte test **490**. This request is translated into an order writing  
11 module **496** which results in the actual order for the test **502**. Since the order needs to be  
12 transmitted to the appropriate organization for execution, an appropriate order is generated to the  
13 microbiology laboratory **500** in this instance. The order results are then achieved **506** and the  
14 completion of the order is reported to the order writing assignment manager **496**. In addition, the  
15 order writing module **502** also results in a task list **504** of orders for various other individuals in  
16 laboratories. In addition, user interface **484** allows the physician to re-enter the physician  
17 resources module at any particular location with results of the tests. These tests are then fed into  
18 the system to continue with the diagnostic algorithm processing of the patient test results **494**.  
19 The user interface also allows interaction with the resident data base **498** Referring to **Figure**  
20 **15** the physician resources database data interface is illustrated. User interface **508** allows the  
21 intensivist to interact with the physician resources data base **510**. In this example, resident data  
22 base **524** which comprises the identification and background of the resident admitting the patient  
23 causes an admission diagnosis **526** to be created. In this example a diagnosis of pancreatitis is

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1 illustrated. This diagnosis of pancreatitis 522 alerts the physician resources module 510 which  
2 causes an entry for the topic pancreatitis 512. The diagnosis algorithm for pancreatitis 514 is  
3 then retrieved and a request for an Apache II score 516 is requested. The system also requests  
4 information for operative data 528 describing what if any operations have taken place with  
5 respect to this patient, vital sign data 530, request for laboratory information 532, past medical  
6 history for the patient 534 and patient demographics 536. All this information is provided to the  
7 Apache II score assignment manager 538 which assigns an Apache II score based upon weighted  
8 composite up to twenty five different variables. This Apache II score is provided to the Apache  
9 II score request module 516. If the severity based Apache II score is greater than or equal to  
10 eight the diagnostic of the system continue 520. If the Apache II score is less than eight, the  
11 patient is triaged to a none ICU bed 518 since the patient will not necessarily require intensive  
12 care thereby saving relatively scarce resources of the ICU for those who are truly critically ill.

13 Referring to **Figure 16** the automated coding/billing work flow and data flow is  
14 illustrated. Clearly ICUs must be paid for the care that they give. At the outset of the visit 540  
15 the user interface 542 allows for the input of ICD 9 diagnosis code information concerning  
16 complexity of the case, whether the patient is stable, whether the physician involved is the  
17 attending physician or consulting physician and all other manner of information required for  
18 billing purposes. In addition, resident data 544 is input such as patient demographics, insurance  
19 information, physician, guarantor, the date that the service is provided. All this information is  
20 provided to the data manager 546 which assembles the required data element for subsequent  
21 processing. The data manager sends the demographic, physician, guarantor, insurance and  
22 related information to a bill generator 548 which begins to assemble of the information to  
23 subsequently generate a bill. Clinical information is provided to the CPT code assignment

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1 manager which assigns codes based upon the scores and user input for bill generation purposes.  
2 A history of present illness (HPI) score 560 is generated along with a review of systems (ROS)  
3 score 562. A PFSH score 564 is generated along with a score relating to the physical exam 566.  
4 An MPM score 568 which is a score relating to the severity of the illness is also generated. All  
5 of these various scores are provided to the CPT assignment manager 558. Periodically  
6 information is downloaded for management reports 556. Once all of the information for the CPT  
7 code assignment is generated that information is provided to the bill generator 548 which  
8 assembles all the data elements needed to generate an HCFA1500 claim form. The input for the  
9 bill generator is then verified 550 where the physician can disagree with code assignments return  
10 progress notes and generally review the bill. This smart processing of the HCFA1500 claim  
11 form allows for fewer mistakes to be made. If there is any error or additional information that is  
12 required, the verification process fails the proposed claim form and information regarding that  
13 failure is provided back to the resident data for completion of any missing items. Once an  
14 invoice has been verified as having the appropriate information to be submitted the HCFA1500  
15 claim form is generated 554. Additional information is written to a billing data file 552 for  
16 importation to the patient accounting system of the present invention.

17 Referring to Figure 17 the order writing data flow is illustrated. Order entry user  
18 interface 600 allows the intensivist to order procedures and medication to assist the patients in  
19 the ICU. For example, the intensivist can order an ECG 604. Thereafter the order is reviewed  
20 and a digital signature relating to the intensivist is supplied 606. Once reviewed and signed off,  
21 the order is approved 607 and sent to the data output system 610. Thereafter the data output  
22 system prints the order to the printer in the ICU 616. For record keeping purposes the order is  
23 exported in the HL7 language to the hospital data system 618. In addition the data output system

Substitute Specification

1 adds an item to the data base that will subsequently cause an intensivist to check the ECG results.  
2 This notification to the task list is provided to the database 614. In addition, as part of the  
3 database an orders file relating to the specific patient is also kept. The fact that and ECG has  
4 been ordered is entered in the orders file for that patient.

5 In a similar fashion using the order entry user interface 600 the intensivist can order  
6 medications 602 for a patient. The medication order then is provided to an order checking  
7 system 608. The order checking system retrieves information from the database 614 relating to  
8 allergies of the patient and medication list which includes medications which are already being  
9 administered to the patient. This allows for the order checking system to check for drug  
10 interactions. Further laboratory data is extracted from the database 614 and the order checking  
11 system checks to insure that there will be no adverse impact of the recommended dosage upon  
12 the renal function of the patient. Once the order checking system 608 is completed, the order is  
13 okayed and provided to the order review and signature module 606. In this module the digital  
14 signature of the intensivist is affixed to the order electronically and the order is approved 607.  
15 Thereafter it is provided to the data output system 610 where again the orders are printed for ICU  
16 and 616 and for the hospital data system. In this case, any medications that are ordered are then  
17 provided to the medications list file in the database 614 so that the complete list of all  
18 medications that are being administered to the ICU patient is current.

19 Referring to Figure 18 the event log is illustrated. The database 620 contains all manner  
20 of notes and data relating to the particular patient that is admitted to the ICU. For example,  
21 admission notes 622 are taken upon admission of the patient and stored in the file that is specific  
22 to that patient. Progress notes 624 are created during the patients stay within the ICU to note the  
23 progress the patient is making giving the various treatments. Procedural notes 626 are also

Substitute Specification

1 created by the intensivist to note what procedures have taken place and what if any events have  
2 occurred associated with those procedures. Laboratory data such as positive blood cultures are  
3 also stored in the file 628 in the database 620. Further x-ray data 630 and abnormal CT Scan  
4 results are stored in the database.

5 The result of these individual files are then provided to an event log manager 632. For  
6 example, admission notes might contain operations performed. Progress notes 624 might relate  
7 to the operations performed. This information is provided to the event log manager 632.

8 Admission information is also input to the event log manager as are a listing of the procedures  
9 administered to the patient. To the extent there are positive blood cultures in the laboratory data  
10 628 those are provided to the event log manager 632 as are abnormal CT scan results. All of this  
11 information is made available through the user interface 634. Thus the event log presents in a  
12 single location key clinical information from throughout a patients stay in the ICU. The event  
13 log user interface provides caregivers with a snapshot view of all salient events since admission.  
14 All relevant data on procedures and laboratory tests, etc. are presented chronologically.

15 Referring to Figure 19 the smart alarms of the present invention are illustrated. The  
16 smart alarm system constantly monitors physiologic data (collected once per minute from the  
17 bedside monitors) and all other clinical information stored in the database (labs, medications,  
18 etc). The periodicity of the collection of data is stated for illustrative purposes only. It is well  
19 within the scope of the present invention to collect physiological data at more frequent time  
20 intervals. Thus, monitor 636 provides information in HL7 form to the interface engine 638. The  
21 physiological data is then formatted by the interface engine for storage in the database 640 where  
22 all patient information is maintained. The rules engine 642 searches for patterns of data  
23 indicative of clinical deterioration.

Substitute Specification

1           One family of alarms looks for changes in vital signs over time, using pre-configured  
2 thresholds. These thresholds are patient-specific and setting/disease-specific. For example,  
3 patients with coronary artery disease can develop myocardial ischemia with relatively minor  
4 increases in heart rate. Heart rate thresholds for patients with active ischemia (e.g. those with  
5 unstable angina in a coronary care unit) are set to detect an absolute heart rate of 75 beats per  
6 minute. In contrast, patients with known coronary artery disease in a surgical ICU have alarms  
7 set to detect either an absolute heart rate of 95 beats per minute or a 20% increase in heart rate  
8 over the baseline. For this alarm, current heart rate, calculated each minute based on the median  
9 value over the preceding 5 minutes, is compared each minute to the baseline value (the median  
10 value over the preceding 4 hours). Physiologic alarms can be based on multiple variables. For  
11 example, one alarm looks for a simultaneous increase in heart rate of 25% and a decrease in  
12 blood pressure of 20%, occurring over a time interval of 2 hours. For this alarm, thresholds were  
13 initially selected based on the known association between changes in these two variables and  
14 adverse clinical events. Actual patient data were then evaluated to determine the magnitude of  
15 change in each variable that yielded the best balance between sensitivity and specificity. This  
16 process was used to set the final thresholds for the rules engine.

17           Alarms also track additional clinical data in the patient database. One alarm tracks  
18 central venous pressure and urine output, because simultaneous decreases in these two variables  
19 can indicate that a patient is developing hypovolemia. Other rules follow laboratory data (e.g.  
20 looking for need to exclude active bleeding and possibly to administer blood).

21           The purpose of the rules engine is to facilitate detection of impending problems and to  
22 automate problem detection thereby allowing for intervention before a condition reaches a crisis  
23 state.

Substitute Specification

Referring to **Figure 20** the procedural note-line log is illustrated. This log allows clinicians to evaluate the likelihood that a given procedure might result in further complications. In this example presented in this **Figure 20** a catheter removal is illustrated. When a new catheter is inserted in a patient **648** a procedural note is created on the procedure note creation user interface **646**. The note is reviewed and a digital signature is attached to the note to associate the note with a particular intensivist **654**. The procedure is then approved and is provided to the data output system **656**. The procedural note is then printed on the printer in the ICU **658** and is exported in HL7 language to the hospital data system **660**. In addition, this also triggers a billing event and the data output system provides appropriate output to the billing module **662** to generate an invoice line item. In addition, the note is stored in the emergency medical record associated with the patient in the database **664**. In addition, the line log is updated in the database **664** to show what procedure was administrated to a patient at what time. If there is an existing catheter, that is displayed to the intensivist at the procedure note creation user interface **646**. This would show an existing catheter changed over a wire **650**. That information is provided to the line id module **652** which extracts information from the line log in the database **664**. This information results in a note being created and provided to the note review and signature module **664**. Thus the line log contains, for each patient, relevant information about all in-dwelling catheters, including type and location of the catheter, insertion date, the most recent date that the catheter was changed over a wire, and the date the catheter was removed. This information helps clinicians evaluate the likelihood that a given catheter is infected and guides its subsequent management of that procedure.

#### Evidence-based Guidelines, Algorithms, and Practice Standards

Substitute Specification

## Decision Support Algorithms

In order to standardize treatment across ICUs at the highest possible level, decision support algorithms are used in the present invention. These include textual material describing the topic, scientific treatments and possible complications. This information is available in real time to assist in all types of clinical decisions from diagnosis to treatment to triage.

All connections among components of the present invention are presently with a high bandwidth T-1 line although this is not meant as a limitation. It is anticipated that other existing and future high bandwidth communication capabilities, both wired and wireless, as well as satellite communications will be suitable for the communications anticipated for the present invention.

As noted earlier, a key objective of the present invention is to standardize care and treatment across ICUs. This is effective in the present invention by providing decision support to intensivists as well as information concerning the latest care and practice standards for any given condition. As noted in Table 1 below, a wide variety of conditions is noted. Each of the conditions has an associated guideline of practice standard that can be presented to the intensivist who might be faced with that particular condition in a patient. These guidelines of practice standards can be accessed at the command center/remote location or at the ICU to assist in the treatment of the patient. Thus, the general categories of cardiovascular, endocrinology, general, gastrointestinal, hematology, infectious diseases, neurology, pharmacology, pulmonary, renal, surgery, toxicology, trauma all have guidelines and practice standards associated with them.

**Table 1**  
**EVIDENCE-BASED GUIDELINES**  
**ALGORITHMS & PRACTICE STANDARDS**

## DECISION SUPPORT

### Substitute Specification

## **CARDIOVASCULAR**

BRADYARRHYTHMIAS  
CARDIOGENIC SHOCK  
CARDIO-PULMONARY RESUSCITATION GUIDELINES  
CONGESTIVE HEART FAILURE  
EMERGENCY CARDIAC PACING  
FLUID RESUSCITATION  
HYPERTENSIVE CRISIS  
**IMPLANTABLE CARDIO-DEFIBRILLATORS**  
INTRA-AORTIC BALLOON DEVICES  
MAGNESIUM ADMINISTRATION IN PATIENTS  
MANAGEMENT OF HYPOTENSION, INOTROPES  
MYOCARDIAL INFARCTION  
MI WITH LEFT BUNDLE BRANCH BLOCK  
PA CATHETER GUIDELINES & TROUBLE-SHOOTING  
PERMANENT PACEMAKERS & INDICATIONS  
PULMONARY EMBOLISM DIAGNOSIS  
PULMONARY EMBOLISM TREATMENT  
SUPRA-VENTRICULAR TACHYARRHYTHMIAS  
UNSTABLE ANGINA  
VENOUS THROMBOEMBOLISM PROPHYLAXIS  
VENOUS THROMBOSIS: DIAGNOSIS & TREATMENT  
VENTRICULAR ARRHYTHMIAS

## **ENDOCRINOLOGY**

ADRENAL INSUFFICIENCY  
DIABETIC KETOACIDOSIS  
HYPERCALCEMIA: DIAGNOSIS & TREATMENT  
HYPERGLYCEMIA: INSULIN TREATMENT  
STEROID REPLACEMENT STRATEGIES  
THYROID DISEASE

## **GENERAL**

DEALING WITH DIFFICULT PATIENTS AND FAMILIES  
END OF LIFE DECISIONS  
ETHICAL GUIDELINES

Substitute Specification

PRESSURE ULCERS  
ORGAN PROCUREMENT GUIDELINES

## **GASTROINTESTINAL**

ANTIBIOTIC ASSOCIATED COLITIS  
HEPATIC ENCEPHALOPATHY  
HEPATIC FAILURE  
MANAGEMENT OF PATIENTS WITH ASCITES  
NUTRITIONAL MANAGEMENT  
ACUTE PANCREATITIS  
UPPER GI BLEEDING: STRESS PROPHYLAXIS  
UPPER GI BLEEDING: NON-VARICEAL  
UPPER GI BLEEDING:VARICEAL

## **HEMATOLOGY**

HEPARIN  
HEPARIN-INDUCED THROMBOCYTOPENIA  
THE BLEEDING PATIENT  
THROMBOCYTOPENIA  
THROMBOLYTIC THERAPY  
TRANSFUSION GUIDELINES  
USE OF HEMATOPOETIC GROWTH FACTORS  
WARFARIN

## **INFECTIOUS DISEASES**

ACALCULUS CHOLECYSTITIS  
ANTIBIOGRAMS  
BLOODSTREAM INFECTIONS  
CANDIDURIA  
CATHETER RELATED SEPTICEMIA  
CATHETER REPLACEMENT STRATEGIES  
ENDOCARDITIS PROPHYLAXIS  
ENDOCARDITIS DIAGNOSIS AND TREATMENT  
FEBRILE NEUTROPENIA  
FUO  
HIV+ PATIENT INFECTIONS  
MENINGITIS  
NECROTIZING SOFT TISSUE INFECTIONS

Substitute Specification



NON-INFECTIOUS CAUSES OF FEVER  
OPHTHALMIC INFECTIONS  
PNEUMONIA, COMMUNITY ACQUIRED  
PNEUMONIA, HOSPITAL ACQUIRED  
SEPTIC SHOCK  
SINUSITIS  
SIRS  
TRANSPLANT INFECTION PROPHYLAXIS  
TRANSPLANT-RELATED INFECTIONS

## **NEUROLOGY**

AGITATION, ANXIETY, DEPRESSION & WITHDRAWAL  
BRAIN DEATH  
GUILLAIN-BARRE SYNDROME  
INTRACEREBRAL HEMORRHAGE  
MYASTHENIA GRAVIS  
NEUROMUSCULAR COMPLICATIONS OF CRITICAL ILLNESS  
NON-TRAUMATIC COMA  
SEDATION  
STATUS EPILEPTICUS  
STROKE  
SUB-ARACHNOID HEMORRHAGE

## **PHARMACOLOGY**

AMINOGLYCOSIDE DOSING AND THERAPEUTIC MONITORING  
AMPHOTERICIN-B TREATMENT GUIDELINES  
ANALGESIA  
ANTIBIOTIC CLASSIFICATION & COSTS  
DRUG CHANGES WITH RENAL DYSFUNCTION  
PENICILLIN ALLERGY  
NEUROMUSCULAR BLOCKERS  
VANCOMYCIN  
THERAPEUTIC DRUG MONITORING

## **PULMONARY**

ARDS: HEMODYNAMIC MANAGEMENT  
ARDS: STEROID USE  
ARDS: VENTILATOR STRATEGIES  
ASTHMA

Substitute Specification

BRONCHODILATOR USE IN VENTILATOR PATIENTS  
BRONCHOSCOPY & THORACENTESIS GUIDELINES  
COPD EXACERBATION & TREATMENT  
CXR (INDICATIONS)  
NONINVASIVE MODES OF VENTILATION  
ENDOTRACHEAL TUBES & TRACHEOTOMY  
TREATMENT OF AIRWAY OBSTRUCTION  
VENTILATOR WEANING PROTOCOL

### **RENAL**

ACUTE RENAL FAILURE :DIAGNOSIS  
ACUTE RENAL FAILURE :MANAGEMENT & TREATMENT  
DIALYSIS  
DIURETIC USE  
HYPERKALEMIA: ETIOLOGY & TREATMENT  
HYPERNATREMIA: ETIOLOGY & TREATMENT  
HYPOKALEMIA: ETIOLOGY & TREATMENT  
HYPONATREMIA: ETIOLOGY & TREATMENT  
OLIGURIA

### **SURGERY**

OBSTETRICAL COMPLICATIONS  
DISSECTING AORTIC ANEURYSM  
POST-OPERATIVE HYPERTENSION  
POST-OPERATIVE MYOCARDIAL ISCHEMIA (NON-CARDIAC  
ARRHYTHMIAS AFTER CARDIAC SURGERY  
POST-OPERATIVE BLEEDING  
POST-OPERATIVE MANAGEMENT OF ABDOMINAL  
POST-OPERATIVE MANAGEMENT OF OPEN HEART  
POST-OPERATIVE MANAGEMENT OF THORACOTOMY  
POST-OPERATIVE POWER WEANING  
POST-OPERATIVE MANAGEMENT OF CAROTID  
WOUND HEALING STRATEGIES

### **TOXICOLOGY**

ACETAMINOPHEN OVERDOSE  
ANAPHYLAXIS  
COCAINE TOXICITY  
ALCOHOL WITHDRAWAL

Substitute Specification

HYPERTHERMIA  
LATEX ALLERGY  
UNKNOWN POISONING

**TRAUMA**

ABDOMINAL COMPARTMENT SYNDROME  
BLUNT ABDOMINAL INJURY  
BLUNT AORTIC INJURY  
BLUNT CARDIAC INJURY  
DVT PROPHYLAXIS  
EXTREMITY COMPARTMENT SYNDROME  
HEAD INJURY  
HYPOTHERMIA  
IDENTIFICATION OF CERVICAL CORD INJURY  
SPINAL CORD INJURY  
OPEN FRACTURES  
PENETRATING ABDOMINAL INJURY  
PENETRATING CHEST INJURY

Referring to **Figures 21A-B**, the acalculous cholecystitis decision support algorithm of the present invention is illustrated. If an intensivist suspects that acalculous cholecystitis may be present, the intensivist may not be certain of all of the aspects that would be indicative of this particular condition. Therefore, the intensivist is lead through a decision support algorithm, which first causes the intensivist to determine if the patient is clinically infected, either febrile or leukocytosis **800**. If this criteria is not met, the intensivist is prompted that it is unlikely that the patient has acalculous cholecystitis **802**.

If the patient is clinically infected **800**, the intensivist is prompted to determine whether the patient has had a previous cholecystectomy **804**. If patient has had a previous cholecystectomy, the intensivist is prompted that it is very unlikely that the patient has acalculous cholecystitis **806**. Alternatively, if a patient has not had a previous cholecystectomy, the intensivist is prompted to determine whether the patient has any of seven (7) risk factors,

Substitute Specification

specifically: 1) Prolonged intensive care unit (ICU) stay (defined as greater than six (6) days); 2) recent surgery (particularly aortic cross clamp procedures); 3) hypotension; 4) positive end-expiratory pressure (PEEP) greater than ten (10) centimeters (cm); 5) transfusion greater than six (6) units of blood; 6) inability to use the gastrointestinal (GI) tract for nutrition; or 7) immunosuppression (AIDS, transplantation, or leukemia) 808. If the patient has none of these seven risk factors, the intensivist is prompted that the patient probably does not have acalculous cholecystitis 810.

If the patient has any of the seven risk factors 808, the intensivist is prompted to determine whether the patient has any of the following symptoms: right upper quadrant (RUQ) tenderness; elevated alkalinephosphatase; elevated bilirubin; or elevated liver transaminases 812. If the patient has none of these four (4) symptoms 812, the intensivist is prompted to consider other more likely sources of infection (see fever of unknown origin or FUO) 814. If the infection remains undiagnosed following an alternative work-up, the intensivist is prompted to re-enter the algorithm 814.

If the patient has any of these four (4) symptoms 812, the intensivist is prompted to determine whether alternative intra-abdominal infectious sources are more likely 816. If alternative intra-abdominal infectious sources are not more likely, the intensivist is prompted to determine whether the patient is sufficiently stable to go for a test 826. If the patient is sufficiently stable to go for a test, the intensivist is prompted to perform an mso4 Cholescintigraphy 836. The normal AC is excluded 838. If the test indicates an abnormality, the intensivist is prompted to consider a cholecystectomy or percutaneous drainage 840. If the patient is not sufficiently stable to go for a test, the intensivist is prompted to perform a bedside ultrasound 828. If no other infectious etiologies are identified and no abnormalities of the gallbladder are noted but: a) the patient remains ill 830, the intensivist is prompted to consider empiric cholecystostomy 832. If no other infectious etiologies are identified and no abnormalities of the gall bladder are noted but: b) the patient is improving 830, the intensivist is prompted to continue to observe the patient 834.

Substitute Specification

1 If alternative intra-abdominal infectious sources are more likely **816**, the intensivist is  
2 prompted to determine whether the patient is sufficiently stable to go for a test **818**. If the patient  
3 is sufficiently stable to go for a test **818**, the intensivist is prompted to perform an abdominal CT  
4 scan **820**. If no other infectious etiologies are apparent and the test: a) demonstrates  
5 abnormalities of the gall-bladder but not diagnostic; or b) no gall-bladder abnormalities are noted  
6 **822**, the intensivist is prompted to maintain continued observation of the patient **824**.  
7 Alternatively, if this criteria not met **822**, the intensivist is prompted to perform an mso4  
8 cholescintigraphy **836**. Normal AC is excluded **838**. If the test is abnormal, the intensivist is  
9 prompted to consider cholecystectomy or precutaneous drainage **840**. If the patient is not  
10 sufficiently stable to go for a test, the intensivist is prompted to perform a bedside ultrasound  
11 **828**. If no other infectious etiologies are identified and no abnormalities of the gall-bladder are  
12 noted but: a) the patient remains ill **830**, the intensivist is prompted to consider empiric  
13 cholecystostomy **832**. If no other infectious etiologies are identified and no abnormalities of the  
14 gall bladder are noted but: b) the patient is improving **830**, the intensivist is prompted to continue  
15 to observe the patient **834**.

16 Referring to **Figure 22**, the adrenal insufficiency decision support algorithm of the  
17 present invention is illustrated. When an intensivist suspects an adrenal problem may be  
18 presented in a patient, the intensivist may initiate the adrenal insufficiency decision support  
19 algorithm which prompts questions concerning all aspects of the condition. First the intensivist  
20 is prompted to determine whether the patient is either hypotensive and/or has been administered  
21 pressors for forty-eight hours or longer **900**. If neither condition is met, the system advises the  
22 intensivist that it is unlikely that an adrenal problem is present **902**.

23 If one or both conditions are met, the intensivist is asked whether an obvious cause for  
24 hypotensive blood pressure or treatment with pressors are manifested, such as hypovolemia or  
25 low blood volume, myocardial dysfunction, or spinal injury **904**. If at least one of these obvious  
26 causes is present, the intensivist is alerted by the system that the underlying cause must first be  
27 treated **906**. If treatment of a suspected underlying cause is reversed, yet the hypotension or

pressor need persists, the intensivist is further directed to determine whether other adrenal problems have occurred in the patient's history **908, 910, 912**

In order to examine prior treatment issues, the intensivist is first prompted by the system to determine if the patient has been treated with steroids in the previous six months for at least a two week period **908**. Next, the intensivist is prompted to determine whether the patient has hyponatremia or hyperkalemia **910**. The intensivist is also prompted to determine whether the patient has experienced anticoagulation or become coagulopathic prior to the hypotension or pressor treatment **912**. According to the responses provided by the intensivist to the system queries or blocks **908, 910, and 912**, the system calculates a treatment action **914** as follows: The array of possible responses to diagnosis questions **908, 910, and 912** are given a Decision Code as shown in Table 1: Adrenal Insufficiency Considerations, below.

Table 1: Adrenal Insufficiency Considerations

Question 1 908	Question 2 910	Question 3 912	Decision Code
N	N	N	A
N	N	Y	A
N	Y	N	B
N	Y	Y	C
Y	Y	Y	C
Y	N	N	D
Y	Y	N	B
Y	N	Y	D
Y	Y	Y	C

1 The possible decision codes of Table 1 are as follows:

Decision Code	Treatment Action
A	Do cosyntropin stim test
B	Consider possible Adrenal Insufficiency. Give decadron 5 mg IV, so cosyntropin stim test and empirically treat with hydrocortione 50 mg IV every 8 hours until stim test results return.
C	Consider possible Adrenal Insufficiency, secondary to adrenal hemorrhage. Give decadron 5 mg IV, so cosyntropin stim test and empirically treat with hydrocortione 50 mg IV every 8 hours until stim test results return.
D	Do cosyntropin stim test, may empirically treat with hydrocortisone 25-50 mg IV every 8 hours until stim test results return

2

3 Besides specialized treatment actions listed in the decision codes above, the intensivist is  
4 directed to administer a cosyntropin stimulation test 914 in order to see how much cortisone the  
5 adrenal gland is producing.

6 After performing the cosyntropin stimulation test, the intensivist is prompted to enter the  
7 patient's level of cortisol before administering cosyntropin and thirty minutes afterwards 916.

8 The software analyzes the test results as follows:

9 The results in Table 2, shown below, are shown as having certain decision codes A through F.

10 **Table 2: Cosyntropin Stimulation Test Results**

<u>basal (A)</u>  <u>&lt; 15</u>	basal (B) 15-20	basal (C) > 25
stim (D) < 5	stim (E) 5-10	stim (F) > 10

11

12 Depending upon the outcome of the analysis of Table 2, one of the treatment actions, shown  
13 below in Table 3, will be displayed 918.

14 **Table 3: Cosyntropin Test Result Treatment Actions**

Decision Code	Treatment Action
A + D	<u>Adrenal insufficiency diagnosed - treat with hydrocortisone 50 mg IV every 8 hours and consider endocrine consult</u>
A + E B + D	Probable Adrenal insufficiency- treat with hydrocortisone 25-50 mg IV every 8 hours and taper as intercurrent illness improves
A + F B + E	Possible Adrenal insufficiency- consider treatment with hydrocortisone 25 mg IV every 8 hours and taper as intercurrent illness improves
A + F B + F C + E C + F	Adrenal insufficiency unlikely- would not treat

1

2 Referring to **Figure 23**, the blunt cardiac injury decision support algorithm of the present  
3 invention is illustrated. If an intensivist suspects that blunt cardiac injury may be present, the  
4 intensivist may not be certain of all aspects that would be critical to or indicative of this  
5 particular condition. Therefore, the intensivist is lead through a decision support algorithm,  
6 which first causes the intensivist to determine whether any of seven (7) risk factors are present:  
7 1) was thoracic impact greater than fifteen (15) mph; 2) was the steering wheel deformed; 3) was  
8 there precordial ecchymosis, contusions, or abrasions; 4) was marked precordial tenderness  
9 present; 5) was there a fractured sternum; 6) were bilateral rib/costal cartilage fractures present;  
10 7) were thoracic spine fractures present **1000**. If none of the 7 risk factors are present, the  
11 intensivist is prompted that no further evaluation is necessary **1002**. If any of the 7 risk factors  
12 are present, the intensivist is prompted to obtain an electrocardiogram (ECG) and chest X-ray  
13 (CXR) **1004**.

14 Once the results of the ECG and CXR are obtained, the intensivist is prompted to  
15 determine: whether the ECG results are abnormal, with abnormal being defined as anything  
16 other than sinus rhythm, including ectopy and unexplained sinus tachycardia (greater than 100



1 beats/minute); and whether the CXR results are abnormal, with abnormal being defined as any  
2 skeletal or pulmonary injury, especially cardiac enlargement **1006**. If either the ECG or CXR are  
3 not abnormal, the intensivist is prompted that a monitored bed is unnecessary for the patient  
4 **1008**. If either the ECG or CXR are abnormal, the intensivist is prompted to determine whether  
5 there is any hemodynamic instability (hemodynamic instability being defined as the absence of  
6 hypovolemia, spinal cord injury, or sepsis) that cannot be explained by hypovolemia, spinal cord  
7 injury, or sepsis **1010**.

8         If this criteria is not met, the intensivist is prompted: that the patient should be in a  
9 monitored bed; that the ECG should be repeated at 24 hours; that, at any time, if unexplained  
10 hemodynamic instability is present, the intensivist should request a stat echo; and that, if blunt  
11 thoracic aortic injury is also suspected, a transesophageal echocardiogram (TEE) is favored over  
12 a transthoracic echocardiogram (TTE) **1012**. Once the results of these tests are obtained, the  
13 intensivist is prompted further to determine whether ectopy, arrhythmia, or abnormality is  
14 present on the ECG **1014**. If none of these criteria are met, the intensivist is prompted that  
15 cardiac injury is excluded **1016**. If any of these criteria are met, the intensivist is prompted that  
16 he should consider monitoring the patient for an additional 24 hours **1018**.

17         If the internist determines that there is any hemodynamic instability that cannot be  
18 explained by hypovolemia, spinal cord injury, or sepsis **1010**, he is prompted: to perform a stat  
19 echo; and, if blunt thoracic aortic injury is also suspected, that a transesophageal echocardiogram  
20 (TEE) is favored over a transthoracic echocardiogram (TTE) **1020**. Once the results of the stat  
21 echo are obtained, the intensivist is prompted to determine whether the echo is abnormal with  
22 possible causes for the abnormality being: pericardial effusion (tamponade; hypokineses or  
23 akinesis (wall motion); dilatation or reduced systolic function; acute valvular dysfunction; and/or

1 chamber rupture **1022**. If the stat echo is abnormal, the intensivist is prompted to treat as  
2 indicated for the particular cause of the abnormality **1026**. If the stat echo is not abnormal, the  
3 intensivist is prompted to continue to monitor the patient and repeat the ECG at 24 hours **1024**.

4       Once the results of the ECG are obtained, the intensivist is prompted to determine  
5 whether ectopy, arrhythmia, or abnormality are present on the ECG **1014**. If this criteria is not  
6 met, the intensivist is prompted that cardiac injury is excluded **1016**. If this criteria is met, the  
7 intensivist is prompted that he should consider monitoring the patient for an additional 24 hours  
8 **1018**.

9       Referring to **Figures 24A-B**, the candiduria decision support algorithm, which is yet  
10 another decision support algorithm of the present invention is illustrated. In the candiduria  
11 decision support algorithm, the intensivist is presented with the criteria for diagnosing  
12 candiduria, or severe fungal infection. First, the intensivist determines whether the patient has  
13 any medical conditions that render the patient prone to fungal infections, such as diabetes, GU  
14 anatomic abnormality, renal transplant, or pyuria **1100**. If there are no such conditions, the  
15 intensivist is next prompted by the system to look for dissemination or spreading of the fungal  
16 infection **1102**. If the infection does not seem to have spread, the intensivist is prompted to  
17 change the patient's catheter and test for pyuria after twenty four hours have passed **1104**.

18       The intensivist is prompted by the system to determine whether the patient can have P.O.  
19 **1106**. If the patient can take P.O., the system next prompts the intensivist to determine whether  
20 azoles, an organic compound for inhibiting fungal growth, have been administered in the past  
21 three days to fight the infection **1108**. If azoles have been previously administered, the systemic  
22 infection diagnosis is confirmed and the intensivist is referred to the systemic amphotericin  
23 dosing algorithm **1110**. If azoles have not been previously administered, directions for the

1 proper treatment dosage of fluconazole (a type of azole) is provided to the intensivist along with  
2 adjustments for the species of fungus found 1112. Where the patient cannot take P.O., the  
3 intensivist is again referred to the systemic amphotericin dosing algorithm 1114.

4 When the patient does have some condition prone to fungal infection, the intensivist is  
5 prompted to determine what other signs of dissemination are exhibited in the patient 1116. The  
6 intensivist is prompted to see if the patient can take P.O. If the patient cannot take P.O., the  
7 intensivist is referred to the systemic amphotericin dosing algorithm 1120. If the patient can take  
8 P.O., the intensivist is prompted to check whether azoles have been administered in the previous  
9 three days 1122. If azoles have been administered, the systemic infection is confirmed and the  
10 intensivist is referred to the systemic amphotericin dosing algorithm 1124. If no azoles have  
11 been administered previously, the intensivist is given instructions for administering fluconazole  
12 to treat the fungal infection 1126.

13 If there is no evidence of dissemination, the intensivist is still prompted to determine  
14 whether the patient can take P.O. 1128. Where the patient cannot take P.O., directions are  
15 provided to administer amphotericin bladder washing procedures 1130. If the patient cannot take  
16 P.O., the intensivist is prompted to determine whether azoles have been administered in the  
17 previous three days 1132. If azoles have been administered, the systemic infection is confirmed  
18 and the intensivist is referred to the systemic amphotericin dosing algorithm 1134. If no azoles  
19 have been administered previously, the intensivist is given instructions for administering  
20 fluconazole to treat the fungal infection 1136.

21 Referring to **Figures 25A-B**, the Cervical Spine Injury decision support algorithm of the  
22 present invention is illustrated. If an intensivist suspects that a cervical spine injury may be  
23 present, the intensivist may not be certain of all of the factors that would be indicative of this  
24

1 particular condition. Therefore, the intensivist is lead through a decision support algorithm,  
2 which first prompts the intensivist to determine if the patient is awake, alert, not intoxicated, and  
3 has no mental status changes 1200. If this criteria is met, the intensivist is prompted to  
4 determine whether the patient has any neck pain 1202. If the patient does not have any neck  
5 pain, the intensivist is prompted to determine whether the patient has any other pain which would  
6 distract from their neck pain 1204. If this criteria is not met, the intensivist is prompted to  
7 determine whether the patient has any neurologic deficits 1206. If this criteria is not met, the  
8 intensivist is prompted that a stable C-spine is present if the patient can flex, extend, move neck  
9 left/right without pain and without neck tenderness to palpitation 1208. The intensivist is  
10 prompted further that he can remove the collar 1208.

11 Alternatively, if the patient does have neck pain 1202, the intensivist is prompted to order  
12 3 x rays 1210 consisting of: 1) lateral view revealing the base of the occiput to the upper border  
13 of the first thoracic vertebra; 2) anteroposterior view revealing spinous processes of the second  
14 cervical through the first thoracic vertebra; and 3) an open mouth odontoid view revealing the  
15 lateral masses of the first cervical vertebra and entire odontoid process 1210. If the x rays are  
16 normal the intensivist is prompted to consider extension then flexion lateral x rays; if normal he  
17 is prompted that he can remove the collar; if abnormal, he is prompted to obtain a surgical  
18 consult 1212. If the x rays are abnormal, the intensivist is prompted to obtain a surgical consult  
19 and order a CT scan 1214. If the x rays are indeterminate, the intensivist is prompted to order a  
20 CT scan 1216.

21 Alternatively, if the patient has no other pain which would distract from their neck pain  
22 1204, the intensivist is prompted to order 3 x rays (the same types of x rays described in 1210  
23 above with the same prompting based on normal, abnormal, or indeterminate x rays) 1218.

1        If the patient does have neurologic deficits **1206**, the intensivist is prompted to determine  
2        whether the neurologic deficit is referable to the cervical spine **1226**. If this criteria is not met,  
3        the intensivist is prompted to order 3 x rays (the same types of x rays described in **1210** above  
4        with the same prompting based on normal, abnormal, or indeterminate x rays) **1218**. If the  
5        neurologic deficit is referable to the cervical spine **1226**, the intensivist is prompted that the  
6        patient should obtain immediate spine trauma surgery consult and CT or MRI (if available) **1228**.

7        Alternatively, if the intensivist determines that the patient does not pass the criteria of  
8        being awake, alert, not intoxicated and having no mental status changes **1200**, the intensivist is  
9        prompted to determine whether the patient has severe head trauma **1232**. If this criteria is met,  
10       the intensivist is prompted to order CT of the neck with head CT **1236**. If this criteria is not met,  
11       the intensivist is prompted to determine whether the patient has any neurologic deficit referable  
12       to the cervical spine **1234**. If the intensivist determines that the patient does have a neurologic  
13       deficit referable to the cervical spine, the intensivist is prompted that the patient should obtain  
14       immediate spine trauma surgery consult and CT or MRI (if available) **1228**. If the intensivist  
15       determines that the patient does not have a neurologic deficit referable to the cervical spine **1234**,  
16       he is prompted to order 3 x rays (the same types of x rays described in **1210** above with the same  
17       prompting based on normal, abnormal, or indeterminate x rays) **1218**.

18       Referring to **Figures 26A-B**, the Oliguria decision support algorithm of the present  
19       invention is illustrated. If an intensivist suspects that Oliguria may be present, the intensivist  
20       may not be certain of all of the aspects that would be indicative of this particular condition.  
21       Therefore, the intensivist is lead through a decision support algorithm, which first causes the  
22       intensivist to determine if the patient is oliguric, with the criteria being passage of less than 25 cc  
23       of urine in a period of 2 hours **1300**. If this criteria is met the intensivist is prompted to

1 determine whether the patient is anuric (the criteria for which is passage of less than 10 cc of  
2 urine in a 2 hour period) in spite of fluid administration **1302**.

3 If this criteria is met, the intensivist is prompted to determine whether the urinary catheter  
4 is working by flushing the catheter **1304**. The intensivist is then prompted to determine whether  
5 the catheter is functioning **1306**. If the catheter is not functioning, the intensivist is prompted to  
6 replace or reposition the catheter **1308**. If the catheter is functioning, the intensivist is prompted  
7 to determine whether the patient has a history of: 1) renal stone disease; 2) abdominal, pelvic, or  
8 retroperitoneal cancer; or 3) recent pelvic or retroperitoneal surgery **1310**. If any of these criteria  
9 are met, the intensivist is prompted to perform the following actions: 1) do renal ultrasound  
10 emergently to rule out obstruction; 2) while waiting for ultrasound, administer fluid at the rate of  
11 7-15 ml/kg of bodyweight; and 3) send urine for specific gravity determination **1312**. Based on  
12 the renal ultrasound test results, the intensivist is prompted to determine whether an obstruction  
13 is present **1314**. If an obstruction is determined to be present, the intensivist is prompted to  
14 consult a urologist immediately **1316**.

15 Alternatively, if the intensivist determines that the patient does not have a history of: 1)  
16 renal stone disease; 2) abdominal, pelvic, or retroperitoneal cancer; or 3) recent pelvic or  
17 retroperitoneal surgery **1310**, the intensivist is prompted to determine whether: 1) the patient has  
18 a history of heart failure or known ejection fraction of less than 30 percent; or 2) there are rales  
19 on the physical exam **1318**.

20 Alternatively, if following the renal ultrasound test, the intensivist determines that there is  
21 no obstruction the intensivist is prompted to determine whether: 1) the patient has a history of  
22 heart failure or known ejection fraction of less than 30 percent; or 2) there are rales on the  
23 physical exam **1318**.

1 If the intensivist determines that the patient is not anuric 1302, then the intensivist is  
2 prompted to determine whether: 1) the patient has a history of heart failure or known ejection  
3 fraction of less than 30 percent; or 2) whether there are rales on the physical examination 1318.  
4 If this criteria is not met, the intensivist is prompted to administer fluids to the patient at the rate  
5 of 10-20 ml/kg of bodyweight 1320 and send the patient's urine sample for a specific gravity test  
6 1322 as more fully described in Figures 26B-C.

7 Alternatively, if the patient does: 1) have a history of heart failure or known ejection  
8 fraction less than 30 percent; or 2) there are rales on the physical exam 1318, the intensivist is  
9 prompted to determine whether there has been a chest x-ray (CXR) in the last 6 hours 1324. If  
10 this criteria is not met, the intensivist is prompted to determine whether there has been a change  
11 in respiratory status 1326. If there has been no change in the respiratory status, the intensivist is  
12 prompted to administer 7-15 ml of fluids per kg of bodyweight 1328 and to send the patient's  
13 urine sample for a specific gravity test.

14 Alternatively, if the intensivist determines that there has been a change in respiratory  
15 status 1326, the intensivist is prompted to: 1) do a chest x-ray; and 2) determine whether there is  
16 evidence of edema or congestion 1334. If there is evidence of edema or congestion 1334, the  
17 intensivist is prompted to: 1) insert a PA catheter to measure wedge pressure and liver function  
18 to direct fluid replacement; and 2) send urine creatinine and sodium 1332.

19 If the intensivist determines that there has been a CXR in the last 6 hours 1324, the  
20 intensivist is prompted to determine whether there is evidence of edema or congestion 1330. If  
21 there is no evidence of edema or congestion, the intensivist is prompted to administer 7-15 ml of  
22 fluids per kg of bodyweight 1328 and send the patient's urine for a specific gravity test 1322.

1           Alternatively, if the intensivist determines there is evidence of edema or congestion 1330,  
2 the intensivist is prompted to: : 1) insert a PA catheter to measure wedge pressure and liver  
3 function to direct fluid replacement; and 2) send urine creatinine and sodium 1332.

4           Referring now to **Figures 26C-D**, the oliguria algorithm description continues.

5           Following the specific gravity test of the patient's urine, the intensivist is prompted to determine  
6 whether the results indicate the specific gravity is less than 1.018. If this criteria is met, the  
7 intensivist is prompted to: 1) send blood and urine immediately to test for blood urea nitrogen  
8 (BUN), creatinine, electrolytes, and Hgb, and spot urine for creatinine, sodium, and sediment;  
9 and 2) administer 5-10 ml of fluid per kg of bodyweight 1356. Once the results of these tests are  
10 obtained, the intensivist is prompted to determine what is the Hgb 1338.

11           If the Hgb has increased by more than 1.5 gm/dl compared to the previous hgb 1340, the  
12 intensivist is prompted to: 1) administer fluids 5-10 ml/kg of bodyweight and follow the urine  
13 output closely 1342. Following this, the intensivist is prompted to determine whether the labs  
14 confirm renal failure by use of the formula  $FE_{Na} = \frac{\text{Urine Na} \times \text{Serum Creatinine}}{\text{Urine Creatinine} \times \text{Serum Na}} \times 100$  1344.

16           If the Hgb is within 1.5 gm/dl from the previous hgb or no comparison 1352, the  
17 intensivist is prompted to determine what is the mean blood pressure 1354. If the mean blood  
18 pressure is determined to be within 20 percent or higher than the baseline blood pressure 1356,  
19 the intensivist is prompted to determine whether the labs confirm renal failure 1344. If the mean  
20 blood pressure is determined to be greater than 20 percent below the baseline pressure 1358, the  
21 intensivist is prompted to give additional fluids and consider invasive hemodynamic monitoring  
22 1360. Following this, the intensivist is prompted to determine whether the labs confirm renal



1 failure by use of the formula  $FE_{Na} = \text{Urine Na} \times \text{Serum Creatinine} / \text{Urine Creatinine} \times \text{Serum Na} \times$   
2 100 1344.

3 Alternatively if the Hgb has decreased by 1.5 gm/dl compared to the previous hgb 1362,  
4 the intensivist is prompted to: 1) transfuse PRBCs as needed; 2) look for source of bleeding and  
5 check PT, aPTT, & platelet count 1364. Following this, the intensivist is prompted to determine  
6 what is the mean blood pressure 1354. If the mean blood pressure is determined to be greater  
7 than 20 percent below the baseline pressure 1358, the intensivist is prompted to give additional  
8 fluids and consider invasive hemodynamic monitoring 1360. Following this, the intensivist is  
9 prompted to determine whether the labs confirm renal failure by use of the formula  $FE_{Na} = \text{Urine}$   
10  $\text{Na} \times \text{Serum Creatinine} / \text{Urine Creatinine} \times \text{Serum Na} \times 100$  1344.

11 If the labs do not confirm renal failure, as indicated by  $FE_{Na} \leq 1$  percent 1346, the  
12 intensivist is prompted to: 1) continue to administer fluids and follow urine output; and 2)  
13 recheck creatinine in 6-12 hours 1348.

14 Alternatively, if the labs do confirm renal failure, as indicated by  $FE_{Na} > 1$  percent 1350,  
15 the intensivist is prompted to: 1) place central venous pressure (CVP); 2) Assure adequate  
16 intravascular volume; 3) give trial of diuretics: 40 mg lasix IV, if no response in 1 hour, give  
17 hydrodiuril 500 mg IV, wait 20-30 minutes then give 100 mg lasix, if persistent oliguria, restrict:  
18 1) fluids; 2) potassium & phosphate; if diuresis ensues, restrict only potassium & phosphate; in  
19 both situations, adjust all renally excreted medications; and 4) see acute renal failure 1350.

20 Referring now to **Figure 26E**, the oliguria algorithm description continues.

21 Alternatively, following the specific gravity test of the patient's urine, the intensivist is prompted  
22 to determine whether the results indicate the specific gravity is greater than or equal to 1.018  
23 1336. If this criteria is not met 1364, the intensivist is prompted to determine whether the urine

1 is dark or tea colored 1366. If this criteria is met, the intensivist is prompted to: 1) check  
2 creatinine phospho/kinase; and 2) force fluids to induce diuresis 1368.

3 If the intensivist determines that the urine is not dark or tea colored, the intensivist is  
4 prompted to: 1) administer 10-20 ml of fluids per kg of bodyweight; and 2) check hgb 1370. The  
5 intensivist is then prompted to determine what is the hgb 1372.

6 If the hgb is determined to be greater than 1.5 gm/dl higher than the previous hgb 1374,  
7 the intensivist is directed to: 1) force fluids; and 2) continue to follow the urine output 1376.

8 Alternatively, if the hgb is determined to be within 1.5 gm/dl of the last hgb or there is no  
9 hgb for comparison 1378, the intensivist is prompted to determine what is the mean blood  
10 pressure 1380. If the mean blood pressure is determined to be 20 percent or higher than the  
11 baseline pressure 1382, the intensivist is prompted to: 1) continue to administer fluids; 2) follow  
12 urine output; and 3) check creatinine in 6-12 hours 1384. If the mean blood pressure is  
13 determined to be greater than 20 percent below the baseline pressure 1386, the intensivist is  
14 prompted to: 1) continue to push fluids; 2) consider invasive hemodynamic monitoring; and 3) if  
15 post-op abdominal trauma, consider abdominal compartment syndrome 1388.

16 If the hgb is determined to be greater than 1.5 gm/dl below the previous hgb 1390, the  
17 intensivist is prompted to: 1) transfuse blood as needed; 2) look for bleeding source; 3) check  
18 PT, aPTT & platelet count; 4) continue to push fluids; and 5) recheck hgb in 1-2 hours 1392.

19 Referring to **Figures 27A-B**, the open fractures decision support algorithm of the present  
20 invention is illustrated. Open fractures are where bone, cartilage, or a tooth break and push  
21 through the skin surface. The intensivist is first prompted by the system to determine whether  
22 the patient has an open fracture 1500. If one has occurred, the intensivist must then determine  
23 whether the wound is contaminated with soil, or was inflicted in a barnyard 1502 in order to

1 address higher risk of infection. If the wound is contaminated with soil, or was inflicted in a  
2 barnyard, the intensivist is prompted to administer a high dose of penicillin to the antibiotics  
3 prescribed **1504**. The intensivist is also prompted to take several treatment steps **1506**. These  
4 treatment steps include administering tetanus prophylaxis, such an antitoxin injection,  
5 monitoring staphylococcus aureus until twenty-four hours after surgery, caring for the wound  
6 within six hours, and where the injury is found to be more severe during surgery, the intensivist  
7 is prompted to administer aminoglycosides for seventy two hours.

8         If the wound is not contaminated with soil, or was inflicted in a barnyard, the intensivist  
9 is next prompted to determine the severity of the wound **1508**. To do so, the intensivist must  
10 determine the length of the wound and corresponding soft tissue damage. If the wound is either  
11 less than one centimeter and clean or greater than a centimeter long without extensive soft tissue  
12 damage, the Intensivist is prompted to take several treatment steps **1506** as previously described.  
13 Where the soft tissue damage is extensive or amputation has occurred, the intensivist is  
14 prompted by the system to make further determinations **1510**, **1512**, **1514** about the wound  
15 caused by the fracture. The intensivist is prompted to determine if enough soft tissue coverage is  
16 remaining for the wound to close and heal **1510**, if any arterial repair is needed **1512**, and if  
17 extensive soft tissue damage with periostitial injury, and bone exposure **1514**. If there is  
18 adequate soft tissue coverage, the intensivist is advised that risk of infection is low and directed  
19 to take treatment actions **1516**. If arterial damage requiring repair is present, the intensivist is  
20 advised by the system that risk of infection is moderate to high and given treatment instructions  
21 **1518**. Where there is soft tissue injury with periostitial stripping and bone exposure, the  
22 intensivist is alerted by the system that risk of infection is high and given treatment instructions  
23 **1520**. The treatment instructions in each case **1516**, **1518**, **1520** include administering tetanus

1 prophylaxis, such an antitoxin injection, caring for the wound within six hours, and performing:  
2 monitoring for staphylococcus aureus, and administering aminoglycosides and high doses of  
3 penicillin, all for seventy two hours before and after any operative procedures.

4 If the intensivist has determined that no exposed fracture has occurred, the system next  
5 prompts the intensivist to determine whether there is any evidence of neuro-vascular damage  
6 **1522**. If there is evidence of neuro-vascular damage, the intensivist is prompted to consult with a  
7 neurosurgeon or vascular surgeon immediately **1524**. If the intensivist determines there is no  
8 evidence of neuro-vascular damage to the patient, the system next prompts the intensivist to  
9 determine whether the patient has compartment syndrome **1526**. If there is evidence of  
10 compartment syndrome seen in the patient, the intensivist is prompted to consult orthopedics  
11 right away **1528**. If there is no evidence of compartment syndrome seen in the patient, the  
12 intensivist is still prompted to consult orthopedics, but without any prompt for time sensitivity  
13 **1530**.

14 Referring to **Figures 28A-B**, the Pancreatitis diagnostic algorithm of the present  
15 invention is illustrated. To evaluate whether a patient has pancreatitis, the intensivist is first  
16 prompted to examine whether severe epigastric abdominal pains and amylase levels three times  
17 greater than normal are present in the patient **1600**. If neither or one of the conditions is present,  
18 the intensivist is prompted to consider other causes of the abdominal pain, such as mesenteric  
19 ischemia, a perforated ulcer, intestinal obstruction, biliary colic, or an ectopic pregnancy **1602**.

20 If severe epigastric abdominal pains and amylase levels three times greater than normal  
21 are present, the intensivist is next prompted to provide the Ranson Criteria which is a criteria  
22 associated with the severity of pancreatitis and the potential outcome or prognosis at that  
23 particular level of severity, or Apache II score which is also a score associated with the severity

1 of the disease and the potential prognosis at a particular level of the patient 1604. If the patient  
2 has a Ranson Criteria less than three or an Apache II score of less than eight, the intensivist is  
3 prompted by the system to consider removing the patient from the Intensive Care Unit 1606.  
4 However, if the patient has a Ranson Criteria greater than three or an Apache II score of greater  
5 than eight, the intensivist is instructed to perform an abdominal ultrasound test within twenty-  
6 four hours 1607. If the results of the ultrasound test show a biliary obstruction, the intensivist is  
7 instructed to consider performing an ERCP to find and remove any gallstones 1608.

8 If the abdominal ultrasound results do not show any biliary obstruction, intensivist is next  
9 prompted to perform more diagnostic tests 1610. The intensivist is directed to perform a  
10 Dynamic IV contrast and an abdominal Computerized Tomography (CT) scan. If the intensivist  
11 does not suspect a surgical condition exists, such as a perforated ulcer, mesenteric infarction or  
12 pancreatic infection, the tests may be performed after three days have passed. If the intensivist  
13 does suspect a surgical condition exists, the tests should be performed within three days. In  
14 either case, if the patient has creatinine levels greater than or equal to 2 milligrams per dl, the  
15 intensivist should not perform the Dynamic IV contrast test.

16 Once the CT scan is performed, the intensivist is prompted to determine whether  
17 necrotizing pancreatitis is present 1612. The intensivist is next required to determine whether  
18 the patient has improved since admission 1614. If no improvement has been seen, the intensivist  
19 is directed to perform percutaneous fluid aspiration and do a gram stain culture the collected  
20 fluid 1616. If the culture shows infection 1618, the intensivist is directed to perform surgical  
21 debridement of the pancreas 1620. If the results of the culture are sterile 1622, the intensivist is  
22 directed to closely follow up on the patient's condition 1624 and watch for clinical deterioration  
23 1626. If the patient does further deteriorate, the intensivist is then instructed to perform a

1 surgical debridement of the pancreas 1628. If the patient does not deteriorate, the intensivist is  
2 still prompted to closely follow the patient's condition 1630.

3 Where the CT scan does not show signs of necrotizing pancreatitis 1612, the intensivist is  
4 prompted by the system to closely observe the patient 1632. The intensivist is also prompted to  
5 check whether clinical deterioration is occurring 1634. If no deterioration is observed, the  
6 intensivist continues to observe the patient's condition 1636. If clinical deterioration is occurring  
7 1634, the intensivist is directed to perform percutaneous fluid aspiration and do a gram stain  
8 culture the collected fluid 1616. If the culture shows infection 1618, the intensivist is directed to  
9 order surgical debridement of the pancreas 1620. If the results of the culture are sterile 1622, the  
10 intensivist is directed to closely follow up on the patient's condition 1624 and watch for clinical  
11 deterioration 1626. If the patient does further deteriorate, the intensivist is then prompted to  
12 order a surgical debridement of the pancreas 1628. If the patient does not deteriorate, the  
13 intensivist is still directed by the system to closely follow the patient's condition 1630.

14 Referring to Figures 29A-B, the penicillin allergy diagnosis algorithm of the present  
15 invention is illustrated. In order to diagnose a penicillin allergy, the intensivist is first prompted  
16 to determine whether the patient has a history suggestive of previous penicillin or cephalosporin  
17 anaphylaxis 1700. Various known reactions, including angioedema, flushing, pruritis, airway  
18 obstruction, syncope, and hypertension, are displayed for the intensivist's review. If the patient  
19 has previously had any of these reactions, the intensivist is prompted to determine whether the  
20 patient has ever taken synthetic or partially synthetic antibiotics, such as ampicillin, amoxicillin,  
21 duricef or kefzol, without any anaphylaxis symptoms 1702. If the patient has taken synthetics  
22 without reaction, the intensivist is advised by the system that penicillin or cephalosporin may be  
23 administered 1716. If the patient has reacted to synthetic or partially synthetic antibiotics, the

1 intensivist is next prompted to determine whether the patient needs penicillin or cephalosporin  
2 specifically 1704.

3 If the patient is not required to have penicillin or cephalosporin, the intensivist is  
4 prompted to administer the synthetic antibiotics 1706. If the patient does need penicillin or  
5 cephalosporin, the intensivist is directed by the system to consider consulting with an allergist or  
6 immunologist and perform skin tests for reactions 1708. Next, the intensivist is prompted to  
7 enter whether the skin test was positive 1710. If the results are negative, the intensivist is further  
8 directed by the system to administer penicillin or cephalosporin with caution, to consider  
9 pretreatment with benadryl or prednisone to counter any reaction, and to closely monitor the  
10 patient 1712. If the results of the skin test are positive, the intensivist is prompted by the system  
11 to perform desensitization procedures 1714.

12 If the patient does not have a history suggestive of previous penicillin or cephalosporin  
13 anaphylaxis 1700, the intensivist is prompted to determine whether the patient has previously  
14 experienced skin-level reactions, such as exfoliative dermatitis, Stevens Johnson Syndrome, or  
15 Toxic Epidermal Necrolysis, when given penicillin or cephalosporin 1718. If the patient has  
16 previously experienced one of these reactions, the intensivist is directed by the system to  
17 administer an alternative antibiotic 1720. If the patient has not experienced one of these  
18 reactions, the intensivist is prompted to determine whether there is a history of any rash when  
19 given penicillin or cephalosporin 1722. If the patient has not previously had a rash when given  
20 penicillin or cephalosporin, the intensivist is advised that the patient will most likely be able to  
21 take penicillin or cephalosporin 1724.

22 If the patient has previously experienced a rash when given penicillin or cephalosporin,  
23 the intensivist is prompted to determine whether the rash presented when the patient was given

1 ampicillin or amoxycillin 1726. If the rash resulted from ampicillin or amoxycillin, the  
2 intensivist is next prompted to determine whether the rash was urticarial 1728. If the rash was  
3 not urticarial, the intensivist is advised by the system that the patient probably can take penicillin  
4 or cephalosporin, but should be closely monitored 1730. If the rash was urticarial, the intensivist  
5 is prompted to determine whether or not the patient needs penicillin or cephalosporin 1704.

6 If the patient is not required to have penicillin or cephalosporin, the intensivist is directed  
7 by the system to administer the synthetic antibiotics 1706. If the patient does need penicillin or  
8 cephalosporin, the intensivist is directed to consider consulting with an allergist or immunologist  
9 and perform skin tests for reactions 1708. Next, the intensivist is prompted to enter whether the  
10 skin test was positive 1710. If the results are negative, the intensivist is further directed to  
11 administer penicillin or cephalosporin with caution, to consider pretreatment with benadryl or  
12 prednisone to counter any reaction, and to closely monitor the patient 1712. If the results of the  
13 skin test are positive, the intensivist is directed to perform desensitization procedures 1714.

14 Referring to **Figures 30A-B**, the Post-Op Hypertension decision support algorithm of the  
15 present invention is illustrated. If an intensivist determines that there may be a possibility of  
16 post-op hypertension, the intensivist may not be certain of all aspects that would be involved in  
17 this particular condition. Therefore, the intensivist is lead through a decision support algorithm  
18 which prompts the intensivist to determine the appropriate care to be given.

19 Initially, the intensivist is prompted to determine whether the patient is hypertensive (BP  
20 greater than 20 percent above mean baseline) 1800. If this criteria is met, the intensivist is  
21 prompted to determine whether the patient has any of the causes of reversible hypertension: 1)  
22 hypercapnia; 2) bladder distension; 3) pain; 4) increased ICP; 5) drugs (pressors, cocaine,  
23 ketamine and chronic MAO use with indirect acting vasopressors); 6) automatic hyperreflexia; or



1 7) volume overload **1802**. If any of these criteria are met, the intensivist is prompted to first treat  
2 those specific etiologies and, if pressure remains high, re-enter algorithm **1804**.

3 Alternatively, if none of these criteria are met **1802**, the intensivist is prompted to  
4 determine whether the patient is at risk of injury from post-op hypertension (i.e., vascular  
5 surgery, coronary artery disease, neurosurgery, ocular surgery, etc.) **1806**. If this criteria is not  
6 met **1806**, the intensivist is prompted to determine whether the BP is greater than 40 percent  
7 above mean baseline **1808**. If this criteria is not met, the intensivist is prompted that the patient  
8 may not need BP treatment **1810**.

9 If the BP is greater than 40 percent above the mean baseline **1808**, the intensivist is  
10 prompted to determine whether the patient is in pain **1812**. If this criteria is met **1812**, the  
11 intensivist is prompted to treat pain and continue **1814**. Following this prompt **1814**, the  
12 intensivist is prompted next to determine whether the patient is actively bleeding or at significant  
13 risk for post-op bleeding (i.e., "moist closure" or high drain output) **1816**. If this criteria is met  
14 **1816**, the intensivist is prompted to use only short acting agents including emolol and  
15 nitroprusside as needed until bleeding has abated **1818**.

16 Alternatively, if this criteria is not met **1816**, the intensivist is prompted to determine  
17 whether the patient is tachycardic (absolute greater than 90 bpm or ((relative greater than 15  
18 percent over baseline)) **1820**. If this criteria is met **1820**, the intensivist is prompted to go to  
19 Decision Table C, which is programmed for the condition of a high heart rate. If this criteria is  
20 not met **1820**, the intensivist is prompted to eliminate (NOT C) Table C and proceed to the next  
21 decision point **1820**.

<u>HR↑Table C</u>							
	CAD	Y	Y	Y	N	N	N

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	RAD	N	Y	Y	N	Y	N
	↓EF	N	N	Y	N	Y	Y
Treatment	1 <sup>ST</sup>	L	E	L	L	A	E
	2 <sup>ND</sup>	E	L	A	N	N	A

- 1  
2 The intensivist is prompted next to determine whether the patient is bradycardic (absolute  
3 less than 60 bpm) 1822. If this criteria is met, the intensivist is prompted to go to Decision Table  
4 B, which is programmed for the condition of a low heart rate.

HR ↓ Table B							
	CAD	Y	Y	Y	N	N	N
	RAD	N	Y	Y	N	Y	N
	↓EF	N	N	Y	N	Y	Y
Treatment	1 <sup>ST</sup>	N	N	A	N	A	A
	2 <sup>ND</sup>	S	S	S	H	H	H

- 5  
6 If this criteria is not met, the intensivist is prompted to eliminate (NOT B) Table B and  
7 proceed to the next decision point 1822. [Note: If NOT C and NOT B, the intensivist is  
8 prompted to go to Table A by default, i.e., If NOT C and NOT B Then A].

HR (nl) Table A							
	CAD	Y	Y	Y	N	N	N
	RAD	N	Y	Y	N	Y	N
	↓EF	N	N	Y	N	Y	Y
Treatment	1 <sup>ST</sup>	L	E	A	N	A	A
	2 <sup>ND</sup>	N	N	E	A	N	N

9

1           The intensivist is prompted next to determine, sequentially, table input values for CAD,  
2   RAD, and EF.

3           In these decision tables, the letter references have the following meanings: L=labetalol,  
4   E=esmolol, A=enalapril, N=nicardipine, H=hydralazine, S=nitroprusside. The reference to 1<sup>st</sup>  
5   and 2<sup>nd</sup> means that treatment should begin with the 1<sup>st</sup> drug and add or substitute the 2<sup>nd</sup> drug as  
6   needed.

7           Using the above decision tables, the intensivist is prompted to determine whether the  
8   patient has known coronary artery disease (CAD) or 3 or more risk factors for CAD 1824. If this  
9   criteria is met 1824, the intensivist is prompted to enter a "Y" or "YES" for CAD into the table  
10   selected above in 1820 and 1822. If this criteria is not met, the intensivist is prompted to enter a  
11   "N" or "NO" for CAD into the table selected above in 1820 and 1822.

12          Next, the intensivist is prompted to determine whether the patient has known reactive  
13   airway disease (RAD)1826. If this criteria is met 1826, the intensivist is prompted to enter a "Y"  
14   or "YES" for RAD into the table selected above in 1820 and 1822. If this criteria is not met, the  
15   intensivist is prompted to enter a "N" or "NO" for RAD into the table selected above in 1820 and  
16   1822.

17          Next, the intensivist is prompted to determine whether the patient has known EF less than  
18   30 percent or a history of systolic heart failure 1828. If this criteria is met 1828, the intensivist is  
19   prompted to enter a "Y" or "YES" for EF into the table selected above in 1820 and 1822. If this  
20   criteria is not met 1828, the intensivist is prompted to enter a "N" or "NO" for EF into the table  
21   selected above in 1820 and 1822.

1 Based on the table selected in **1820** and **1822** above, and the table inputs determined from  
2 **1824**, **1826**, and **1828**, the intensivist is prompted with the proper medication to administer for  
3 the 1<sup>st</sup> and 2<sup>nd</sup> treatment.

4 If the patient is not in pain **1812**, the intensivist is prompted to employ the procedures  
5 described above in **1816**.

6 If the patient is at risk of injury from post-op hypertension **1806**, the intensivist is  
7 prompted to determine whether the blood pressure is greater than 40 percent above baseline  
8 **1830**. If this criteria is met **1830**, the intensivist is prompted to employ the procedures described  
9 above in **1812**.

10 Alternatively, if this criteria is not met **1830**, the intensivist is prompted to determine  
11 whether the patient is in pain **1836**. If this criteria is met **1836**, the intensivist is prompted to  
12 treat pain and reevaluate following analgesia and, if still hypertensive, to continue algorithm  
13 **1838**. Following this action **1838**, the intensivist is prompted to employ the procedures  
14 described above in **1816**. If the patient is not in pain **1836**, the intensivist is prompted to employ  
15 the procedures described above in **1816**.

16 If the patient is determined not to be hypertensive **1800**, the intensivist is prompted to  
17 determine whether the patient requires their BP controlled near baseline (i.e., neurosurgery,  
18 carotid surgery, thoracic aorta surgery) **1832**. If this criteria is not met **1832**, the intensivist is  
19 prompted that the patient probably does not need treatment **1834**.

20 Alternatively, if this criteria is met **1832**, the intensivist is prompted to employ the  
21 procedures described above in **1836**.

22 Referring to **Figure 31A**, the pulmonary embolism diagnosis algorithm is illustrated. If a  
23 pulmonary embolism is suspected, the intensivist is first prompted to determine whether the

1 patient is hemodynamically unstable **2900**. If the patient is hemodynamically unstable, the  
2 intensivist is directed by the system to consider performing an immediate transthoracic  
3 echocardiogram, pulmonary angiogram and treatment consistent with massive pulmonary  
4 embolism **2902**. If the patient is not hemodynamically unstable, the intensivist is prompted to  
5 perform a VQ scan and perform further assessment of the patient **2904**.

6 In order to further assess the patient, the intensivist is prompted to respond to a series of  
7 questions **2906, 2908, 2910, 2912**. The intensivist is prompted to determine whether any of the  
8 following patient conditions are present: Dyspnea, Worsening chronic dyspnea, Pleuritic chest  
9 pain, Chest pain that is non- retro sternal & non- pleuritic, O<sub>2</sub> saturation < 92% on room air that  
10 corrects with 40% O<sub>2</sub> supplementation, Hemoptysis, or Pleural rub **2906**. The intensivist is also  
11 prompted to determine whether any risk factors are in the patient's history, such as: Surgery  
12 within 12 weeks, Immobilization (complete bed rest) for > 3 days within 4 weeks, Previous DVT  
13 or objectively diagnosed PE, Lower extremity fracture & immobilization within 12 weeks,  
14 Strong family history of DVT or PE(  $\geq 2$  family members with objective proven events or 1<sup>st</sup>  
15 degree relative with hereditary thrombophilia), Cancer (treatment within the last 6 months or  
16 palliative stages), Postpartum, or Lower extremity paralysis **2908**. Further, the intensivist must  
17 determine whether the patient has any of the following symptoms: Heart rate > 90 beats/min,  
18 Temp  $\geq 38.0$ , CXR free of abnormalities (edema, pneumonia, pneumothorax), or Leg symptoms  
19 c/w DVT, syncope, blood pressure less than 90 mm Hg with heart rate greater than 100  
20 beats/min, receiving mechanical ventilation and/or oxygen supplementation greater than 40%,  
21 and new onset or right heart failure (-JVP, new S1, Q3, T3, or RBBB) **2910**. The intensivist is  
22 also queried by the system to consider alternative diagnosis that may be more likely than  
23 pulmonary embolism. To do so, the intensivist is prompted to consider conditions that simulate

1 major pulmonary embolism, such as myocardial infarction, acute infection with COPD, septic  
2 Shock, dissecting aortic aneurysm, or occult hemorrhage. The intensivist is additionally  
3 prompted to consider conditions that simulate minor pulmonary embolism, such as acute  
4 bronchitis, pericarditis, viral pleurisy, pneumonia, and esophageal spasm 2912.

5 Referring to **Figure 31B**, the pulmonary embolism algorithm description continues. The  
6 intensivist enters the answers to the assessment queries posed 2906, 2908, 2910, 2912 into the  
7 system. If two or more responses to the patient condition query 2906 were answered yes and one  
8 or more questions were answered yes from: Heart rate > 90 beats/min, Temp  $\geq$  38.0, CXR free of  
9 abnormalities, or Leg symptoms c/w DVT of the symptoms query 2910, the intensivist is  
10 informed that a typical pulmonary embolism is present 2914. Next, the system compares this  
11 response to the answer to the alternative diagnosis query 2912. If an alternative diagnosis is at  
12 least as likely as pulmonary embolism 2916, the intensivist is also given a low probability 2918  
13 to moderate probability 2920 risk factor. If an alternative diagnosis is less likely than pulmonary  
14 embolism 2922, the intensivist is given a moderate 2924 to high 2926 probability risk factor.

15 If less than two yes answers resulted from the patient conditions 2906, the intensivist is  
16 advised by the system that an atypical pulmonary embolism may be present 2928. Next, the  
17 system compares this response to the answer to the alternative diagnosis query 2912. If an  
18 alternative diagnosis is at least as likely as pulmonary embolism 2930, the intensivist is told there  
19 is no risk and low probability 2932 or some risk with a low probability 2934 risk factor. If an  
20 alternative diagnosis is less likely than pulmonary embolism 2934, the intensivist is given a no  
21 risk and low probability 2938 to risk but moderate probability 2940.

22 If at least one answer to the symptoms of syncope, blood pressure less than 90 mm Hg  
23 with heart rate greater than 100 beats/min, receiving mechanical ventilation and/or oxygen

supplementation greater than 40%, and new onset or right heart failure 2910 is yes, the intensivist is prompted with a message that severe pulmonary embolism is occurring 2942. Next, the system compares this response to the answer to the alternative diagnosis query 2912. If an alternative diagnosis is at least as likely as pulmonary embolism 2944, the intensivist is told there is a moderate probability of pulmonary embolism 2946. If an alternative diagnosis is less likely than pulmonary embolism 2948, the intensivist is notified that a high probability of pulmonary embolism is present 2950.

Once the risk factors and probabilities are determined the system compares this information to the VQ scan results. This comparison is performed according to the following Table 4 below.

**Table 4: Probability table**

<u>Input</u>	<u>Clinical Probability</u>		
<u>V/Q Scan</u>	High	Moderate	Low
High	A	A	B
Intermediate	B	C	C
Low	B	C	E
Normal	E	E	E

Where the VQ scan column and the risk column intersect, a letter code is assigned to various treatment instructions. The treatment instructions are as follows.

**A = Pulmonary embolus diagnosed. Begin treatment**

**E = Pulmonary embolus excluded**

**B = Proceed with the following work-up:**

**1) Perform spiral CT(If patient has renal insufficiency [creatinine > 2.0], consider going directly**

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- 1 to pulmonary angiogram to reduce the potential dye load). If positive begin treatment,  
2 2) If negative, assess for DVT using compression ultrasound or venography. If positive begin  
3 treatment,  
4 3) If negative, perform pulmonary angiogram. If positive begin treatment, if negative diagnosis  
5 excluded.

6  
7 C = Proceed with the following work-up:

- 8 1) Perform spiral CT. If positive begin treatment,  
9 2) If negative, assess for DVT using compression ultrasound or venography. If positive begin  
10 treatment,  
11 3) If negative perform D-dimer assay(elisa only). If negative diagnosis excluded, If positive,  
12 perform serial ultrasound of the lower extremities.

13  
14 Once the correlation is made, the instructions associated with the letter code are displayed by the  
15 system to prompt the intensivist with diagnosis and treatment instructions.

16 Referring to **Figure 32**, the seizure decision support algorithm of the present invention is  
17 illustrated. If an intensivist encounters seizure in a patient, he may not be certain of all of the  
18 aspects and the timelines that are critical to treating this particular condition. Therefore, the  
19 intensivist is lead through a decision support algorithm, which divides the treatment sequence  
20 into three segments: 0-30 minutes; 30-60 minutes; and beyond 60 minutes.

21 At the onset of a seizure, in the 0-30 minute segment of the algorithm, the intensivist is  
22 prompted to give the patient lorazepam (0.1 mg/kg of bodyweight) in 2 mg boluses up to 8 mg  
23 **2000**. Subsequently, the intensivist is prompted to give the patient phenytoin (18-20 mg/kg of  
24 bodyweight) at 50mg/min of fosphenytoin (18-20 mg/kg of bodyweight) at 150 mg/min followed  
25 by 5 mg/kg of bodyweight/day through separate IV line **2002**.

26 During the 30-60 minute segment of the algorithm, the intensivist is prompted to: reload  
27 additional phenytoin or fosphenytoin (10 mg/kg of bodyweight) maintaining previous infusion;  
28 and give additional lorazepam (0.05 mg/kg of bodyweight) **2004**. Subsequently, the intensivist is  
29 prompted to begin continuous EEG monitoring **2006**.

30 The intensivist is then prompted to determine whether the patient is hemodynamically



1    stable **2008**. If hemodynamically stable, the intensivist is prompted to administer propofol 1-2  
2    mg/kg of bodyweight bolus followed by 2-10 mg/kg/hr **2010**.

3            At the 60 minute segment of the algorithm, the intensivist is prompted that if seizure  
4    activity stops, he should taper either midazolam or propofol over the next 12-24 hours while  
5    maintaining phenytoin but if seizures persist, he is prompted to move to the pentobarbital coma  
6    block **2012**.

7            Under pentobarbital coma, the intensivist is prompted to administer 10-15 mg/kg/hr and  
8    to maintain until seizure control is achieved on EEG **2014**. The intensivist is prompted further  
9    that the patient usually requires PA catheter and pressors to maintain hemodynamic control **2014**.

10           Alternatively, if the patient is determined to be hemodynamically unstable **2016**, the  
11    intensivist is prompted to utilize fluids and pressors as needed (phynylephrine or dopamine)  
12    midazolam 0.2 mg/kg bolus followed by 0.1-2.0 mg/kg/hr **2018**.

13           At the 60 minute segment of the algorithm, the intensivist is prompted that if seizure  
14    activity stops, he should taper either midazolam or propofol over the next 12-24 hours while  
15    maintain phenytoin but if seizures persist, he is prompted to move to the pentobarbital coma  
16    block **2012**.

17           Under pentobarbital coma, the intensivist is prompted to administer 10-15 mg/kg/hr and  
18    to maintain until seizure control is achieved on EEG **2014**. The intensivist is prompted further  
19    that the patient usually requires PA catheter and pressors to maintain hemodynamic control **2014**.

20           Referring to **Figures 33A-B**, the supra ventricular tachycardia (SVT) decision support  
21    algorithm of the present invention is illustrated. If an intensivist determines that SVT is present,  
22    the intensivist may not be certain of all aspects that would be involved in treating this particular

1 condition. Therefore, the intensivist is lead through a decision support algorithm which prompts  
2 the intensivist to determine the appropriate care to be given.

3 Initially, the intensivist is prompted to determine whether SVT is stable or unstable **2100**.

4 If SVT is stable **2102**, the intensivist is prompted to determine whether the patient has a regular  
5 or irregular rhythm **2102**. If the patient has a regular rhythm **2104**, the intensivist is prompted to  
6 determine whether there is a wide complex or a narrow complex **2104**. If the intensivist  
7 determines that there is a wide complex **2106**, the intensivist is prompted to administer adenosine  
8 6 mg/12 mg (if needed) **2108**. Following the administering of adenosine **2108**, the intensivist is  
9 prompted to consider that if the patient converts to sinus rhythm (SR) to – consider re-entrant  
10 junctional or WPW re-entrant. If the wide complex recurs, treat the patient with esmolol or  
11 Ca+2 blockers.

12 Alternatively; if no effect, the intensivist is prompted to consider V-tach **2112**. Next, the  
13 intensivist is prompted to: 1) load procainamide 150 mg over 10 min, then 1 mg/min infusion;  
14 and 2) synchronized cardiovert **2114**.

15 Alternatively, if the wide complex slows, the intensivist is prompted to consider SVT w/  
16 aberrancy and continue to slow with esmolol or Ca+2 blockers **2116**.

17 The intensivist is prompted next to administer esmolol/calcium blockers and link to  
18 ventricular rate control **2118**. The intensivist is prompted next to determine whether there has  
19 been a conversion to SR **2120**. If there is no conversion to SR in 24 hours, the intensivist is  
20 prompted to add antiarrhythmic agent and consider anticoagulation **2122**. The intensivist is  
21 prompted next to determine whether there has been conversion to SR. If conversion to SR, the  
22 intensivist is prompted to continue maintenance antiarrhythmic agent during hospitalization  
23 **2124**. If no conversion to SR, the intensivist is prompted to cardiovert while on antiarrhythmic

1    & following heparinization **2126**.

2           If the patient has a regular rhythm **2104**, the intensivist is prompted to determine whether  
3    there is a wide complex or a narrow complex **2104**. If the intensivist determines that there is a  
4    narrow complex **2128**, the intensivist is prompted to to administer adenosine 6mg/12mg (if  
5    needed) **2130**. If administering the adenosine **2130** slows the ventricular rate only and the atrial  
6    rate persists, the intensivist is prompted to consider atrial flutter and continue to slow with  
7    esmolol or Ca+2 blockers **2132**. The intensivist is prompted next to employ the procedures  
8    described above in **2118**.

9           If administering the adenosine **2130** converts the patient to SR, the intensivist is  
10   prompted to consider re-entrant sinus or junctional and if recurs, treat with esmolol or Ca+2  
11   blockers **2134**.

12          If administering the adenosine **2130** slows both atrial and ventricular rates the intensivist  
13   is prompted that there is a probable sinus tachycardia **2136**. The intensivist is prompted next to  
14   continue to slow with esmolol **2138**. The intensivist is prompted next to employ the procedures  
15   described above in **2118**.

16          If SVT is stable **2102**, the intensivist is also prompted to determine whether the patient  
17   has a regular or irregular rhythm **2102**. If the patient has an irregular rhythm **2140**, the  
18   intensivist is prompted that if no p waves, there is probable Atrial fibrillation **2142**. The  
19   intensivist is prompted next to slow ventricular response with esmolol or Ca+2 blockers **2144**.  
20   The intensivist is prompted next to employ the procedures described above in **2118**.

21          If the patient has an irregular rhythm **2140**, the intensivist is prompted to determine  
22   whether there are more than 3 p wave types MAT – and to treat underlying lung dz. and avoid  
23   theophylline compounds **2146**. The intensivist is prompted next to slow rate with Ca+2 blockers

1 only **2148**. The intensivist is prompted next to employ the procedures described above in **2118**.

2 Referring now to **Fig. 33C**, the description of the SVT decision algorithm continues. If  
3 SVT is unstable **2101**, the intensivist is prompted to determine whether the patient has SBP less  
4 than 80, ischemia, mental status changes **2150**. The intensivist is prompted next to perform  
5 synchronous cardioversion (100 J, 200 J, 300 J) **2152**. The intensivist is prompted next that if  
6 sinus rhythm: 1) correct reversible etiologies; 2) consider starting IV antiarrhythmic for  
7 maintenance of sinus rhythm **2154**. Alternatively, following **2152**, the intensivist is prompted  
8 next that if continued SVT: 1) correct reversible etiologies; 2) load IV antiarrhythmic (see dosing  
9 guidelines) and repeat DC cardioversion **2156**.

10 For example, and without limitations, wide complex QRS Tachycardia is also addressed  
11 in the decision support algorithm of the present invention. Referring to **Figures 34A-B**, the wide  
12 complex QRS tachycardia decision support algorithm is illustrated. If an intensivist determines  
13 that there may be a possibility of wide complex QRS tachycardia, the intensivist may not be  
14 certain of all aspects that would be involved in this particular condition. Therefore, the  
15 intensivist is lead through a decision support algorithm which prompts the intensivist to  
16 determine the appropriate care to be given.

17 Initially, the intensivist is prompted to determine whether the patient is hemodynamically  
18 stable (no angina, heart failure, or hypotension (systolic less than 80 mm)) **2200**. If this criteria  
19 is not met, the intensivist is prompted to go to the cardio-pulmonary guidelines algorithm which  
20 is generally known to those skilled in the art.

21 Alternatively, if this criteria is met, the intensivist is prompted to determine whether the  
22 patient is within 7 days of a myocardial infarction or at risk for myocardial ischemia **2202**. If the  
23 patient is not within 7 days of a myocardial infarction or at risk for myocardial ischemia **2202**,

1 the intensivist is prompted to determine whether the wide complex QRS rhythm is sustained  
2 (greater than 30 seconds) **2234**. If this criteria is not met, the intensivist is prompted to  
3 determined whether the QRS is monomorphic **2236**. If the QRS is monomorphic **2236**, the  
4 intensivist is prompted to determine whether the patient has structural heart disease **2242**. If the  
5 patient has structural heart disease **2242**, the intensivist is prompted to: 1) monitor closely; 2)  
6 look for reversible etiologies; and 3) consider antiarrhythmic therapy **2244**. If the patient does  
7 not have structural heart disease **2242**, the intensivist is prompted to: 1) monitor closely; 2) look  
8 for reversible etiologies; and 3) if recurs and symptomatic may require further testing (prolonged  
9 holter or EP study) **2246**.

10 If the QRS is not monomorphic **2236**, the intensivist is prompted to determine whether  
11 the QT is prolonged **2238**. If this criteria is met, the intensivist is prompted to: 1) check K; 2)  
12 give Mg; and 3) consider overdrive pacing **2240**. If the intensivist determines that the QT is not  
13 prolonged, **2238**, the intensivist is prompted to employ the procedures described above in **2242**.

14 If the wide complex QRS rhythm is sustained **2234**, the intensivist is prompted to  
15 determine whether the rhythm is polymorphic or irregular **2208**. If the rhythm is polymorphic or  
16 irregular, the intensivist is prompted to consider atrial fibrillation with accessory pathway  
17 conduction and load with procainamide and get a cardiology consultation **2210**. If the rhythm is  
18 not polymorphic or irregular, the intensivist is prompted with the question of whether he wishes  
19 to: 1) perform ECG diagnosis; or 2) administer adenosine diagnostically **2220**. If the intensivist  
20 makes the determination to perform an ECG diagnosis **2220**, he is prompted to go to the ECG  
21 diagnosis algorithm **2300**.

22 If the intensivist makes the determination to administer adenosine diagnostically **2220**, he  
23 is prompted to go to the administer adenosine branch of the algorithm **2222**. If there is no effect,

1 the intensivist is prompted that there is probable VT and to determine whether the VT is  
2 monomorphic **2224**. If the VT is monomorphic **2224**, the intensivist is prompted to load with  
3 procainamide and perform synchronous cardioversion **2226**.

4 Alternatively, if the VT is not monomorphic **2224**, the intensivist is prompted to load  
5 with lidocaine and perform immediate cardioversion **2228**.

6 If the ventricular response is slowed after administering adenosine **2222**, the intensivist is  
7 prompted to consider SVT with aberrancy and treat with esmolol or Ca blockers **2230**.

8 If the ventricular response converts to sinus rhythm after administering adenosine **2222**,  
9 the intensivist is prompted: to consider re-entrant mechanism with BBB or WPW; and, 1) if  
10 WPW consult cardiology for possible ablation **2232**.

11 If the patient is within 7 days of a myocardial infarction or at risk for myocardial  
12 ischemia **2202**, the intensivist is prompted to determine whether the wide complex is sustained  
13 (30 seconds) **2204**. If the wide complex is not sustained **2204**, the intensivist is prompted to  
14 determine whether the patient: 1) symptomatic; 2) tachycardia runs are frequent; or 3) the  
15 tachycardia rates are rapid (greater than 180) **2212**. If this criteria is not met, the intensivist is  
16 prompted to observe **2216**. Alternatively, if this criteria is met **2212**, the intensivist is prompted  
17 to: 1) administer lidocaine 100-200 mg & 1-4 mg/min infusion; and 2) amiodarone **2214**.

18 If the wide complex is sustained **2204**, the intensivist is prompted to determine whether  
19 the rate is greater than 140/min **2206**. If this criteria is not met **2206**, the intensivist is prompted:  
20 to consider accelerated idioventricular, and that in some patients this can lead to hemodynamic  
21 compromise; and that 1) he can perform overdrive pacing if needed **2218**.

22 Alternatively, if this criteria is met, the intensivist is prompted to follow the procedures in  
23 **2208**.

1        If the intensivist makes the determination to perform ECG Diagnosis **2220**, he is  
2        prompted to go to the ECG Diagnosis branch of the algorithm **2220**. Referring now to Figure  
3        34C, in the ECG Diagnosis branch, the intensivist is prompted to determine whether the patient  
4        has known pre-excitation syndrome **2300**. If this criteria is met, the intensivist is prompted to  
5        determine whether the QRS complexes are predominantly negative in leads V4-V6 **2302**. If the  
6        QRS complexes are predominantly negative in leads V4-V6, the intensivist is prompted that  
7        there is probable VT **2304**.

8        If the QRS complexes are not predominantly negative in leads V4-V6 **2302**, the  
9        intensivist is prompted to determine whether there is a QR complex in one or more of leads V2-  
10       V6 **2306**. If this criteria is met, the intensivist is prompted that there is probable VT **2308**.

11       Alternatively, if this criteria is not met **2306**, the intensivist is prompted to determine  
12       whether there are more QRS complexes than P waves **2310**. If there are more QRS complexes  
13       than P waves **2310**, the intensivist is prompted that there is probable VT **2312**. If there are not  
14       more QRS complexes than P waves **2310**, the intensivist is prompted: to consider pre-excited  
15       SVT; and that he may wish to perform EP study **2314**.

16       If the intensivist determines that the patient does not have known pre-excitation  
17       syndrome **2300**, the intensivist is prompted to determine whether there is an RS complex present  
18       in any precordial lead **2316**. If this criteria is not met **2316**, the intensivist is prompted that there  
19       is probable VT **2318**.

20       Alternatively, if this criteria is met **2316**, the intensivist is prompted to determine whether  
21       the R to S interval is greater than 100 MS in any one precordial lead **2320**. If this criteria is met,  
22       the intensivist is prompted that there is probable VT **2322**.

23       If the R to S interval is not greater than 100 MS in any one precordial lead **2320**, the

1 intensivist is prompted to determine whether there is evidence of atrioventricular dissociation

2 **2324**. If this criteria is met, the intensivist is prompted that there is probable VT **2326**.

3 Alternatively, if there is no evidence of atrioventricular dissociation **2324**, the intensivist  
4 is prompted to determine whether V-1 is negative and V-6 positive and QRS greater than 0.14  
5 mSEC **2328**. If this criteria is met, the intensivist is prompted that there is probable VT **2330**.

6 If this criteria is not met **2328**, the intensivist is prompted that the situation may represent  
7 SVT with aberrancy or underlying bundle branch block **2332**.

8 Referring to **Figure 35A**, the assessment of sedation algorithm of the present invention is  
9 illustrated. If an intensivist encounters a need for sedation, he may not be certain of all of the  
10 aspects and the timelines that are critical to this particular process. Therefore, the intensivist is  
11 lead through a decision support algorithm, which prompts the intensivist to address a number of  
12 factors in the process **3100**.

13 The intensivist is prompted initially to go to the Scoring section of the algorithm **3100**.  
14 The intensivist is prompted to proceed through a number of scorings **3102** and to first score the  
15 patient's alertness with points being allocated in the following manner: asleep/unresponsive=0;  
16 responsive to voice=1; and hyperresponsive=2 **3104**.

17 The intensivist is prompted next to score the patient's movement with points being  
18 allocated in the following manner: no spontaneous movement=0; spontaneous movement=1; and  
19 pulls at lines, tubes, dressings=2 **3106**.

20 The intensivist is prompted next to score the patient's respiration based on whether the  
21 patient is mechanically ventilated or spontaneously breathing with points being allocated as  
22 subsequently discussed. If the patient is mechanically ventilated, the intensivist is prompted to  
23 allocate points in the following manner: no spontaneous ventilation=0; spontaneous ventilations



1 and synchronous with ventilator=1; or spontaneous ventilations with cough or dysynchrony>10  
2 percent of breaths=2 **3108**. Alternatively, if the patient is spontaneously breathing, the  
3 intensivist is prompted to allocate points in the following manner: respiration rate (RR) <10=0;  
4 RR=10-30=1; or RR>30=2 **3108**.

5 The intensivist is prompted next to score the patient's heart rate with points being  
6 allocated in the following manner: >20 percent below mean for last 4 hr=0; within 20 percent  
7 mean for last 4 hr=1; or >20 percent above mean for last 4 hr=2 **3110**.

8 The intensivist is prompted next to score the patient's blood pressure with points being  
9 allocated in the following manner: MAP >20 percent for last 4 hr=0; MAP within 20 percent  
10 mean for last 4 hr=1; or MAP >20 percent above mean for last 4 hr=2 **3112**.

11 The intensivist is prompted next to determine the sedation score by the following  
12 formula: SEDATION SCORE=alertness + movement + respirations + heart rate + blood  
13 pressure **3114**. In one embodiment, respiratory rate, heart rate, and BP can be computer linked to  
14 monitor data thereby simplifying the sedation scoring assessment. The nursing observations are  
15 deemed intuitive and the nursing burden in sedation scoring can be minimal by using this point  
16 scoring.

17 Referring now to **Figure 35B**, the sedation assessment algorithm description continues.  
18 The intensivist is prompted then to continue the sedation assessment by moving to the Pain  
19 Assessment section of the algorithm **3116**.

20 In the Pain Assessment section, the intensivist is prompted to determine whether the  
21 patient is conscious, communicative, and acknowledging pain **3118**. If this criteria is not met,  
22 the intensivist is prompted to determine: whether the sedation score is greater than 2 and the  
23 patient: is known to be in pain before becoming uncommunicative; or S/p recent surgery; or

1 having tissue ischemia or infarct; or has wounds; or has large tumor possibly impinging on  
2 nerves. If the answer to either of these two questions is YES, the intensivist is prompted to treat  
3 for pain **3118**. The intensivist is prompted then to continue the assessment by moving to the  
4 Delirium Assessment section of the algorithm **3118**.

5 In the Delirium Assessment section, the intensivist is prompted to determine whether the  
6 sedation score is greater than 2 AND the patient has: day/night reversal with increased agitation  
7 at night OR eyes open and “awake” but disoriented; or eyes open and “awake” but pulling at  
8 lines, tubes, or dressings OR difficult to sedate prior to ventilator weaning OR paradoxical  
9 response to benzodiazepines. If this criteria is met, the intensivist is prompted to consider  
10 butyrophenone **3120**.

11 Referring to **Figure 36**, the Bolus sliding scale algorithm is illustrated. If an intensivist  
12 encounters a need for sedation, the algorithm for which may contain a reference to the bolus  
13 sliding scale for midazolam, he may not be certain of all of the aspects which are critical to this  
14 scale. Therefore, the intensivist is lead through a decision support algorithm, which prompts the  
15 intensivist through the use of the scale **3200**.

16 If lorazepam is less than 0-2 mg IV q 6hr, then the intensivist is prompted to give  
17 midazolam 1-2 mg q 5 min until adequately sedated **3202**.

18 Alternatively, if lorazepam equals 2-4 mg IV q 4 hr, then the intensivist is prompted to  
19 give midazolam 2 mg q 5 min until adequately sedated **3202**.

20 Alternatively, if lorazepam is greater than 10 mg IV q 4 hr, then the intensivist is  
21 prompted to give midazolam 5 mg q 5 min until adequately AND consider fentanyl and/or  
22 droperidol or Haldol for synergy despite delirium and pain assessment **3202**.

23 Yet another decision support routine is the sedation algorithm. Referring to **Figure 37**,

1 the sedation process decision support algorithm is illustrated. If an intensivist determines that a  
2 patient will require sedation, the intensivist may not be certain of all aspects that would be  
3 involved in this particular process. Therefore, the intensivist is lead through a decision support  
4 algorithm, which prompts the intensivist to conduct a sedation assessment based on: 1) scoring;  
5 2) pain; and 3) delirium (see Assessment of Sedation algorithm) 3300.

6 Following completion of the sedation assessment process 3300, the intensivist is  
7 prompted to determine whether the patient is in pain 3302. If this criteria is met, the intensivist  
8 is prompted to administer bolus morphine, fentanyl, other narcotic, start patient controlled  
9 analgesic (PCA) or epidural analgesia as indicated 3324. If the patient is not in pain 3302 or  
10 after administering bolus morphine, fentanyl, other narcotic, start patient controlled analgesic  
11 (PCA) or epidural analgesia as indicated 3324, the intensivist is prompted to determine whether  
12 the patient is delirious 3304.

13 If the intensivist determines that the patient is delirious 3304, he is prompted to  
14 administer droperidol 2.5-5 mg q30min prn and that he may consider IV Haldol not to exceed  
15 30mg/24hr 3326. If the patient is not delirious or after following the procedures in 3326, the  
16 intensivist is prompted to determine whether the patient will need sedation for more than the next  
17 24 hours 3306. If the patient will not need sedation for more than the next 24 hours 3306, the  
18 process continues as described in Figure 38.

19 Alternatively, if the patient will need sedation for more than the next 24 hours 3306, the  
20 intensivist is prompted to determine whether the sedation score is 8-10 3308. If this criteria is  
21 met, the intensivist is prompted to employ the Bolus sliding scale midazolam and increase  
22 lorazepam by 20 percent 3328 (see Bolus sliding scale midazolam algorithm – Figure 36).  
23 Subsequently, the intensivist is prompted to reassess sedation in 4 hr 3330.

1           If the sedation score is not 8-10, the intensivist is prompted to determine whether the  
2 sedation score is greater than or equal to the last Sed Scr after sedative bolus or increase 3310. If  
3 this criteria is met, the intensivist is prompted to employ the procedures described above in 3328  
4 and 3330.

5           If the sedation score is not greater than or equal to the last Sed Scr after sedative bolus or  
6 increase 3310, the intensivist is prompted to determine whether four (4) or more midaz boluses  
7 have been given since last q4hr assessment 3312. If this criteria is met, the intensivist is  
8 prompted to employ the procedures described above in 3328 and 3330.

9           Alternatively, if less than four (4) midaz boluses have been given since last q4hr  
10 assessment 3312, the intensivist is prompted to determine whether the patient is adequately  
11 sedated 3314. If this criteria is not met, the intensivist is prompted to employ the procedure  
12 described in 3328 and 3330.

13           If the intensivist determines that the patient is adequately sedated 3314, the intensivist is  
14 prompted to determine whether the sedation score is 0-2 3316. If this criteria is met, the  
15 intensivist is prompted to decrease lorazepam by 20 percent 3332 and reassess sedation in 4 hr  
16 3334.

17           Alternatively, if the sedation score is not 0-2 3316, the intensivist is prompted to  
18 determine whether the sedation score is less than or equal to the last Sed Scr after sedative  
19 decrease 3318. If this criteria is met, the intensivist is prompted to employ the procedure  
20 described in 3332 and 3334.

21           If the sedation score is not less than or equal to the last Sec Scr after sedative increase  
22 3318, the intensivist is prompted to determine whether the patient is clinically oversedated 3320.  
23 If the patient is clinically oversedated 3320, the intensivist is prompted to employ the procedure

1 described in 3332 and 3334. If the patient is not clinically oversedated 3320, the intensivist is  
2 prompted to reassess sedation in 4 hr 3322.

3 Referring to **Figure 38**, the short term sedation process decision support algorithm of the  
4 present invention is illustrated. If an intensivist determines that a patient will not require  
5 sedation past the next 24 hour period, the intensivist may not be certain of all aspects that would  
6 be involved in this particular process. Therefore, the intensivist is lead through a decision  
7 support algorithm, which prompts the intensivist to conduct a sedation assessment based on: 1)  
8 scoring; 2) pain; and 3) delirium (see Assessment of Sedation algorithm) 3100.

9 Following completion of the sedation assessment process 3100, the intensivist is  
10 prompted to decrease lorazepam by 20 percent from baseline per day 3102. The intensivist is  
11 prompted next to determine whether the patient is in pain 3104. If this criteria is met, the  
12 intensivist is prompted to administer bolus morphine or fentanyl 3122. If the patient is not in  
13 pain or after administering bolus morphine or fentanyl 3122, the intensivist is prompted to  
14 determine whether the patient is delirious 3106.

15 If the intensivist determines that the patient is delirious, he is prompted to administer  
16 droperidol 2.5-5 mg q30min prn 3124. If the patient is not delirious or after administering  
17 droperidol 3124, the intensivist is prompted to determine whether the sedation score is 8-10  
18 3108.

19 If this criteria is met, the intensivist is prompted to employ the Bolus sliding scale  
20 midazolam (see Bolus sliding scale midazolam algorithm) and begin midazolam infusion or  
21 begin propofol 1-2 mg/kg bolus and 5-50 mcg/kg/min infusion 3126. Subsequently, the  
22 intensivist is prompted to reassess sedation in 1 hr 3128.

23 If the sedation score is not 8-10, the intensivist is prompted to determine whether the

1 sedation score is greater than or equal to the last Sed Scr after sedative bolus or increase **3110**. If  
2 this criteria is met, the intensivist is prompted to employ the procedures described above in **3126**  
3 and **3128**.

4 If the intensivist determines that the sedation score is not greater than the last sedation  
5 score after sedative bolus or increase **3110**, the intensivist is prompted to determine whether the  
6 patient is adequately sedated **3112**. If this criteria is not met, the intensivist is prompted to  
7 employ the procedures described above in **3126** and **3128**.

8 If the intensivist determines that the patient is adequately sedated **3112**, he is prompted to  
9 determine whether the sedation score is 0-2 **3114**. If this criteria is met, the intensivist is  
10 prompted to determine if the patient has been sedated for more than 72 hours **3130**. If the  
11 patient has not been sedated for more than 72 hours **3130**, the intensivist is prompted to hold  
12 midazolam or propofol and hold or decrease lorazepam by 50 percent **3132**. The intensivist is  
13 prompted subsequently to reassess sedation in 1 hour **3134**.

14 Alternatively, if the intensivist determines that the patient has been sedated for more than  
15 72 hours **3130**, the intensivist is prompted to hold midazolam or propofol and decrease  
16 lorazepam by 20 percent per day **3136**. The intensivist is prompted subsequently to reassess  
17 sedation in 1 hour **3134**.

18 Alternatively, if the intensivist determines that the sedation score is not 0-2 **3114**,  
19 the intensivist is prompted to determine whether the sedation score is less than or equal to the  
20 last sedation screening after sedative decrease **3116**. If this criteria is met, the intensivist is  
21 prompted to determine whether the patient has been sedated for more than 72 hours and to  
22 follow the procedures described above in **3130**.

1           If the intensivist determines that the sedation score is not less than or equal to the  
2 last Sed Scr after sedative decrease 3116, the intensivist is prompted to determine whether the  
3 patient is clinically oversedated 3118. If this criteria is met, the intensivist is prompted to  
4 determine whether the patient has been sedated for more than 72 hours and to follow the  
5 procedures described above in 3130. If this criteria is not met, the intensivist is prompted to  
6 reassess sedation in 1 hr 3120.

7           Referring to **Figure 39**, the respiratory isolation decision support algorithm is illustrated.  
8 If an intensivist determines that there may be a need for respiratory isolation, the intensivist may  
9 not be certain of all aspects that would be involved in this process. Therefore, the intensivist is  
10 lead through a decision support algorithm which prompts the intensivist to determine the need  
11 for respiratory isolation based upon: a) clinical assessment; and/or b) smear/culture findings  
12 **3500**.

13           Pursuing the clinical assessment branch of the decision support algorithm, the intensivist  
14 is prompted to determine whether the patient has known mTB (mycobacterium tuberculosis)  
15 **3502**. If this criteria is met, the intensivist is prompted to determine whether the patient has been  
16 compliant with their medications for over 2 weeks and is clinically responding **3512**. If the  
17 patient has not been compliant with their medications for over 2 weeks and is not clinically  
18 responding **3512**, the intensivist is prompted that isolation is required **3514**. If the patient has  
19 been compliant with their medications and is clinically responding **3512**, the intensivist is  
20 prompted that no isolation is required **3516**.

21           Alternatively, if the patient does not have known mTB **3502**, the intensivist is prompted  
22 to determine whether the patient has known mycobacterial disease other than TB **3504**. If this  
23 criteria is met, the intensivist is prompted to determine whether the patient has new CXR (chest x

1 ray) findings and symptoms (cough 2 weeks, fever, weight loss) **3518**. If the patient does not  
2 have new CXR findings and symptoms **3518**, the intensivist is prompted that no isolation is  
3 required **3520**. If the patient does have new CXR findings and symptoms **3518**, the intensivist is  
4 prompted that isolation is required **3522**.

5 If the patient does not have known mycobacterial disease other than TB **3504**, the  
6 intensivist is prompted to determine whether there is a new cavitary lesion on CXR **3506**. If this  
7 criteria is met, the intensivist is prompted that isolation is required **3524**.

8 Alternatively, if there is no new cavitary lesion on CXR **3506**, the intensivist is prompted  
9 to determine whether there are pulmonary infiltrates or whether the patient is HIV (human  
10 immunodeficiency virus) positive **3508**. If this criteria is not met, the intensivist is prompted that  
11 no isolation is required **3510**. If this criteria is met, the intensivist is prompted to determine  
12 whether the patient has new CXR findings and symptoms (cough 2 weeks, fever, weight loss)  
13 **and** at high risk: 1) known mTB exposure; 2) homeless; 3) prisoner; 4) travel to area with multi-  
14 drug resistant TB **3526**. If this criteria is met, the intensivist is prompted that isolation is  
15 required **3528**. Alternatively, if this criteria is not met, the intensivist is prompted that no  
16 isolation is required **3530**.

17 Pursuing the smear/culture branch of the decision support algorithm **3500**, the intensivist  
18 is prompted to determine whether the AFB (acid-fast bacilli) smear is positive **3532**. If the AFB  
19 smear is not positive, the intensivist is prompted that: no isolation is required; await culture  
20 results; if culture negative, no isolation required; if culture positive and patient has mycobacterial  
21 disease other than TB (MOTT no isolation is required; if the culture is positive and the patient  
22 does not have MOTT consult ID **3534**.



1           Alternatively, if the AFB smear is positive, the intensivist is prompted to determine  
2 whether the patient has known mycobacterial disease other than TB 3536. If this criteria is not  
3 met, the intensivist is prompted that isolation is required 3538. If this criteria is met, the  
4 intensivist is prompted: to isolate until results of NAP test are in; if mTB positive isolate the  
5 patient; if no mTB, no isolation is required 3540.

6           Referring to **Figure 40**, the empiric meningitis treatment decision support algorithm of  
7 the present invention is illustrated. If the intensivist is treating a patient for meningitis, the  
8 intensivist is prompted to answer a series of queries by the system to properly address  
9 medication and dosage. First, the intensivist is prompted to determine whether the patient has  
10 suffered a head trauma or undergone neurosurgery 3700. The answer to this question is input 1  
11 to **table x** below. The intensivist is next prompted to determine whether the patient is allergic to  
12 penicillin or is from an area where penicillin resistant staphylococcus pneumoniae is prevalent  
13 3702. The answer to this question becomes input 2 to **table x** below. The intensivist must also  
14 determine whether the patient is immunocompromised 3704, and the answer becomes input 3 to  
15 **table x** below. The intensivist determines if the patient is over fifty years of age 3706, with the  
16 answer being input 4 in **table x** below. Lastly, the intensivist is prompted to determine whether  
17 the patient has altered mental status 3708, and the answer becomes input 5 in **table x** below. The  
18 inputs to each of these prompts 3702, 3704, 3706, 3708 is compared to a dosage database  
19 according to the **Table 5** below.

20   **Table 5: Meningitis Input-Output Table**

Input	Combinations	Output
1	1 = yes 2 = no	A) vancomycin 1.5 – 2 gm IV q 12h + ceftazedine 2gm IV q 8 hr or cefapime 2gm IV q 8 hr
2	1 = yes	B) vancomycin

Substitute Specification

	2 = no	1.5 – 2 gm IV q 12h + aztreonam 0.5 – 2 gm IV q 6-8 hr
3	1 = no 2 = no 3 = no 4 = yes	<u>ampicillin 2 gm IV q 4h</u>  + ceftriaxone 2 gm IV q12 cefotaxime 2 gm IV q 6 h
4	1 = no 2 = no 3 = no 4 = no	<u>ceftriaxone 2 gm IV q 12 hr</u>  or cefotaxime 2 gm IV q 6 hr
5	1 = no 2 = no 3 = yes	<u>ampicillin 2 gm IV q 4 hr</u>  + ceftazidime 2 gm IV q 8 hr or cefipime 2 gm IV q 8 hr
6	1 = no 2 = yes 3 = no 4 = yes	<u>vancomycin 1.5 – 2 gm IV q 12 hr</u>  + chloramphenicol 1 gm IV q 6 hr
7	1 = no 2 = yes 3 = no 4 = no	
8	1 = no 2 = yes 3 = yes	
9	5 = yes to inputs 3-8	add to output consider acyclovir 10 mg/kg IV q 8h

In the Meningitis Input-Output Table, possible combinations of the five inputs are listed. For the conditions manifested in the patient, different drugs and dosages will be required. The proper treatment for each combination is listed in the output column of **Table x**. After the algorithm runs the comparison, the output is displayed on the computer screen, prompting the intensivist with the proper treatment **3712**.

Referring to **Figure 41A**, the ventilator weaning decision support algorithm of the present invention is illustrated. The ventilator weaning decision support algorithm is used to determine whether an intensive care unit patient can return to breathing unassisted, and discontinue use of a ventilator. Such a determination requires evaluation of the patient by the

1 intensivist over the course of several days.

2 To begin the decision process of whether to wean a patient from ventilator use, the  
3 intensivist is prompted to conduct daily screening, preferably during the hours of 06:00 a.m. to  
4 10:00 a.m 3800. The daily screen prompts the intensivist to determine whether: the patients P/F  
5 ratio is greater than 200, the patient's positive end-expiratory pressure (PEEP) is less than or  
6 equal to 5, whether cough suctioning has been adequate and/or spontaneous, infusions with  
7 vasopressors have been necessary, and continuous infusions of sedatives or neuromuscular  
8 blocking agents have been necessary 3800. If all conditions 3802 are answered no, the  
9 intensivist is directed by the system to repeat the daily screen 3805 the following morning. If all  
10 the conditions of the daily screen are met 3802, the intensivist is prompted to perform additional  
11 tests.

12 If the patient has satisfied the daily screen, the intensivist is next directed to conduct a  
13 rapid shallow breathing test 3804. To perform the test, the intensivist is directed to change the  
14 ventilator setting to continuous positive airway pressure (CPAP) less than or equal to 5. In other  
15 words, there is no intermittent mandatory ventilation or pressure support provided for the patient.  
16 The patient is given one minute to reach a steady state of breathing. Then the intensivist  
17 measures the ratio of breaths per minute to tidal volume ( $f/V_T$ ). The intensivist next is prompted  
18 to determine whether the patient's  $f/V_T$  is less than or equal to 105 breathes per minute 3806. If  
19 the patient's  $f/V_T$  is greater than 105 breathes per minute, the intensivist is prompted to return to  
20 performing daily screening the following morning 3808.

21 If the patient's  $f/V_T$  is less than or equal to 105 breathes per minute, the intensivist is next  
22 directed to perform a trial of spontaneous breathing. Here, the intensivist can either insert a T-  
23 Piece in the patient's airway or reduce the patient's CPAP to less than or equal to 5 over the

1 course of two hours. The intensivist is prompted to observe the patient periodically in order to  
2 evaluate if the patient is breathing without assistance **3810**. The intensivist is prompted to  
3 perform a periodic assessment by determining whether: the patient's breathing characteristics  
4 are greater than 35 breaths per minute for 5 minutes, or SpO<sub>2</sub> is less than 90%, or the patient's  
5 Heart Rate (HR) is greater than 140, or HR deviates from the baseline breathing rate by more than  
6 20%, or the patient's SBP is outside the range of 90 to 180. If any of the conditions are met, the  
7 intensivist is directed by the system to terminate ventilator weaning **3812**. If the conditions are  
8 not met, the patient is further assessed.

9 In further assessment, the intensivist is prompted to determine whether the patient has  
10 been able to breathe spontaneously for two hours, keep a clear airway, and does not have any  
11 procedures scheduled within twenty-four hours that would require the patient to be intubated  
12 **3814**. If the patient meets all of these criteria **3814**, the intensivist is notified by the system that  
13 the patient may be extubated **3816**. If the patient does not meet one or more of the criteria **3814**,  
14 the intensivist is prompted to perform steps for progressive weaning **3818**.

15 Referring to **Figure 41B**, the ventilator weaning decision support algorithm of the present  
16 invention is further illustrated. The intensivist, at his or her discretion may choose either T-  
17 piece progressive weaning or pressure support progressive weaning. In order to perform T-piece  
18 progressive weaning, the intensivist is directed to repeat the trial of spontaneous breathing (as  
19 previously described **3810**). The intensivist can either insert a T-piece in the patient's airway or  
20 reduce the patient's CPAP to less than or equal to 5 over the course of two hours. The intensivist  
21 is prompted to perform periodic assessment of the patient by either a two hour or 30 minute trial  
22 **3820**.

23 In order to perform pressure support progressive weaning, the intensivist is first prompted

1 to observe whether the patient's pressure support (PS) rating is equal to eighteen plus or minus  
2 the positive end-expiratory pressure (PEEP). Next, the intensivist is directed by the system to  
3 regulate the pressure values in order to keep the patient's respiratory rate (RR) between twenty  
4 and thirty. Next, the intensivist is directed by the system to decrease the patient's pressure  
5 support by 2-4 centimeters of water two times per day. Once the patient maintains pressure  
6 support for at least two hours, the intensivist is prompted to further pursue extubating the patient  
7 3822.

8 After either T-Piece progressive weaning 3820 or pressure support progressive weaning  
9 3822, the intensivist is next prompted to perform a periodic assessment of the patient. Here, the  
10 intensivist must determine whether whether: the patient's breathing characteristics are greater  
11 than 35 breaths per minute for 5 minutes, or SpO<sub>2</sub> is less than 90%, or the patient's HR is grater  
12 than 140, or HR deviates from the baseline breathing rate by more than 20%, or the patient's  
13 SBP is outside the range of 90 to 180. Where the patient meets any of these criteria, the  
14 intensivist is prompted to terminate weaning. If the patient meets none of these criteria, the  
15 intensivist is prompted to further assess the patient's ability to breath spontaneously 3824.

16 In further assessment, the intensivist is prompted to determine whether the patient has  
17 been able to breathe spontaneously for two hours, keep a clear airway, and does not have any  
18 procedures scheduled within twenty-four hours that would require the patient to be intubated  
19 3826. If the patient meets all of these criteria 3814, the intensivist is notified by the system that  
20 the patient may be extubated 3828. If the patient does not meet one or more of the criteria 3826,  
21 the intensivist is directed by the system to allow the patient to rest for at least twelve hours at  
22 A/C, the last level of pressure support the patient achieved 3830. The intensivist is prompted to  
23 resume progressive weaning the following day 3832.

Referring to Figure 42, the Warfarin Dosing Algorithm of the present invention is illustrated. The intensivist is first prompted to give the initial dose and determine subsequent dosage each day 3900. When the intensivist determines subsequent dosage, he is first prompted to determine the patient's target INR 3902. If the patient's target INR ranges from 2.0 to 3.0, the intensivist is prompted by the system to make further determinations relevant to dosage. The intensivist is directed by the system to determine whether the patient is taking drugs that effect prothrombin time 3904, the baseline INR value 3906, and whether rapid anticoagulation is required 3908. Each answer is assigned a point value, and the total points are tabulated. If the point value is greater than one, the system refers to the 10 milligram load target database for dosing. If the point value is less than one, the system refers to the 5 milligram load target database for dosing 3910.

At the initial INR determination 3902, if the patient's INR was initially between 1.5 and 2.0, the system refers to the 5 milligram load target database for dosing. If the patient's INR was initially between 3.0 and 4.0, the system refers to the 10 milligram load target database for dosing 3910. Next the intensivist is prompted to enter the day of treatment 3912 and the patient's INR 3914. Depending on whether the system has been directed to the 5 milligram load target or the 10 milligram load target, a comparison is run 3916 according to the following tables.

**5 mg Load Target INR 1.5-2.0**

Day	<1.5	1.5-2	2-2.5	>2.5
2	5	1.25 - 2.5	0	0
3	5-7.5	1.25 - 2.5	0 - 1.25	0
	10- (Check to			

4	see whether pt has received vit K)	1.25 - 2.5	0 - 1.25	0
5	10 (Check to see whether pt Has received vit K)	2.5 - 5	0 - 2.5	0 - 1.25
6	15 Obtain hematology consultation.	2.5 - 5	1.25 - 2.5	0 - 1.25

### 10 mg Load Target INR 3.0-4.0

Day	<1.5	1.5-2	2-2.5	2.5-3	>3
2	10	7.5 - 10	5-7.5	2.5-5.0	0-2.5
3	10 -15	7.5 - 10	5-7.5	2.5 - 5	2.5-5
4	10 -15 (Check to see whether pt has received vit K)	7.5 -12.5	5 - 10	5-7.5	2.5-5
5	15 (Check to see whether pt has received vit K)	10 - 12.5	7.5-10	5 - 7.5	2.5-5
6	15-20 obtain hematology consultation.	10 - 15	7.5-12.5	5 - 10	5-7.5

The appropriate dosage and instructions is displayed on the computer screen to the intensivist 3918.

Referring to Figure 43, the heparin-induced thrombocytopenia (HIT) decision support algorithm of the present invention is illustrated. The intensivist is prompted to observe whether the patient's platelet count has dropped 50% or more over seventy-two hours while being treated with heparin, and whether any other obvious causes of platelet reduction might be present 4100. If such a drop has not occurred, the intensivist is notified by the system that the patient most likely does not have HIT, but monitoring of the platelet count should continue 4102. If the patient's platelet count has drastically dropped, the intensivist is prompted to determine whether

1 the patient has been treated with heparin for more than three days **4104**. Regardless of the  
2 answer, the intensivist is next prompted to determine if the patient has been treated with heparin  
3 in the preceeding three months **4106**. If the patient has not received heparin in the preceeding  
4 three months, the intensivist is notified by the system that HIT is not likely to be the cause of the  
5 platelet drop. The intensivist is also prompted to monitor platelet count for infection or other  
6 thrombocytopenia-causing drugs, and to consider stopping heparin therapy if the platelet count  
7 drops below 50,000 per cubic millimeter **4108**.

8 If the patient has received heparin in the last three days **4104**, the intensivist is further  
9 prompted to look for signs of thrombosis, or blood clotting **4110**. If the patient shows signs of  
10 thrombosis, the intensivist is notified by the system that the patient is likely to have HIT.  
11 Accordingly, the intensivist is prompted to stop administering heparin and flush any drug  
12 administration equipment that would contain heparin traces. The intensivist is also provided  
13 instructions by the system to treat a patient still requiring anticoagulation treatment with alternate  
14 drugs and methods **4112**.

15 Where the patient does not show signs of thrombosis **4110**, the intensivist is prompted to  
16 check for heparin resistance **4114**. Signs of heparin resistance include inability to hold aPTT  
17 though heparin doses have been increase. If the patient shows signs of heparin resistance, the  
18 intensivist is prompted to consider stopping heparin treatment and to consider treating a patient  
19 still requiring anticoagulation treatment with alternate drugs and methods **4116**. If the patient  
20 does not show signs of heparin resistance, the intensivist is notified by the system that the patient  
21 possibly has HIT. The intensivist is accordingly prompted to continue monitoring for  
22 thrombosis, consider infection or other drugs that cause throbocytopenia, and to consider  
23 stopping heparin therapy if the platelet count drops below 50,000 per cubic millimeter **4118**.



## 1   **Results**

2           The structure of the present invention and its efficacy have yielded striking results in  
3   practice. In a research setting, deployment of certain rudimentary aspects of the present the  
4   invention designed to experimentally test the approach described and developed in detail above,  
5   yielded unprecedented improvements in clinical and economic outcomes: 50% improvement in  
6   severity adjusted mortality, 40% improvement in clinical complication rates, 30% improvement  
7   in ICU length of stay, and 30% improvement in overall ICU cost of care.

8           A system and method of remote monitoring of ICU's and other healthcare locations has  
9   been shown. It will be apparent to those skilled in the art that other variations of the present  
10   invention are possible without departing from the scope of the invention as disclosed. For  
11   example, one can envision different ratios of command center/remote location to ICU's, other  
12   decision support algorithms that would be used by intensivists, other types of remote monitoring  
13   of not only ICU's but other types of hospital functions as well as industrial functions where  
14   critical expertise is in limited supply but where that expertise must be applied to ongoing  
15   processes. In such cases a system such as that described can be employed to monitor processes  
16   and to provide standardized interventions across a number of geographically dispersed locations  
17   and operations.